# Fluent 2020R1

## 流体新功能

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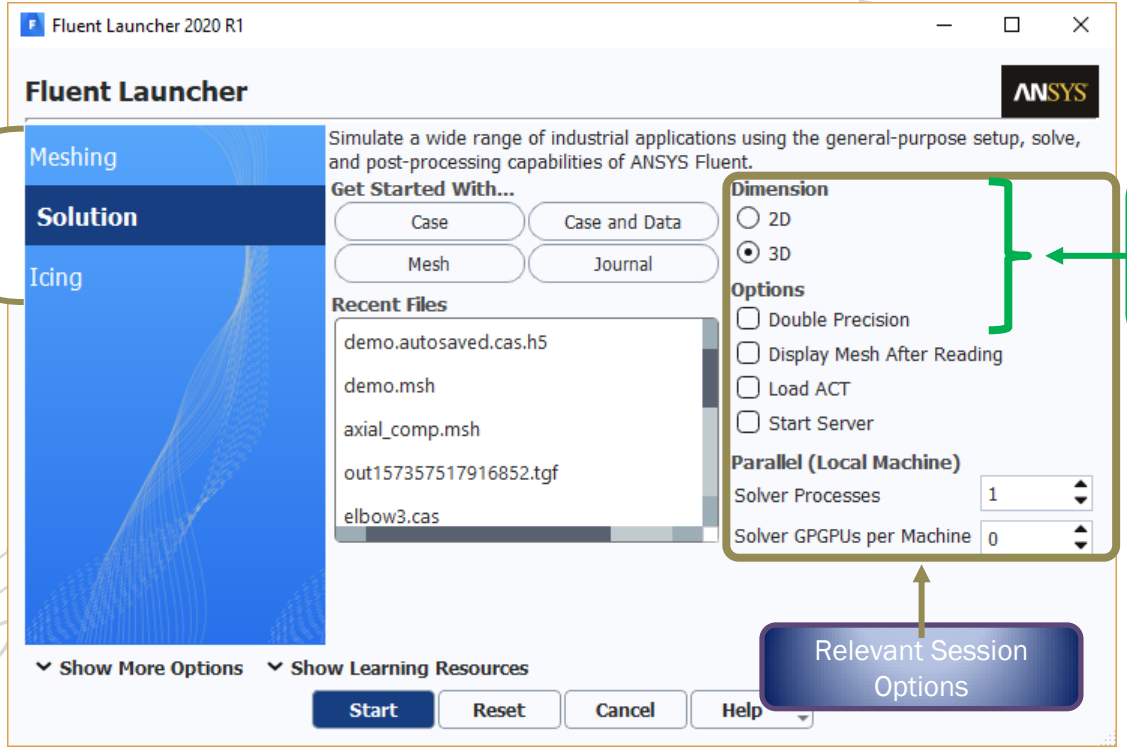
# Fluent新启动界面

在网格划分和求解模式以及其它应用之间进行选择




从已存储的网格和case信息自动更新计算维度和精度选项

Relevant Session Options

其它选项/ 学习资源链接

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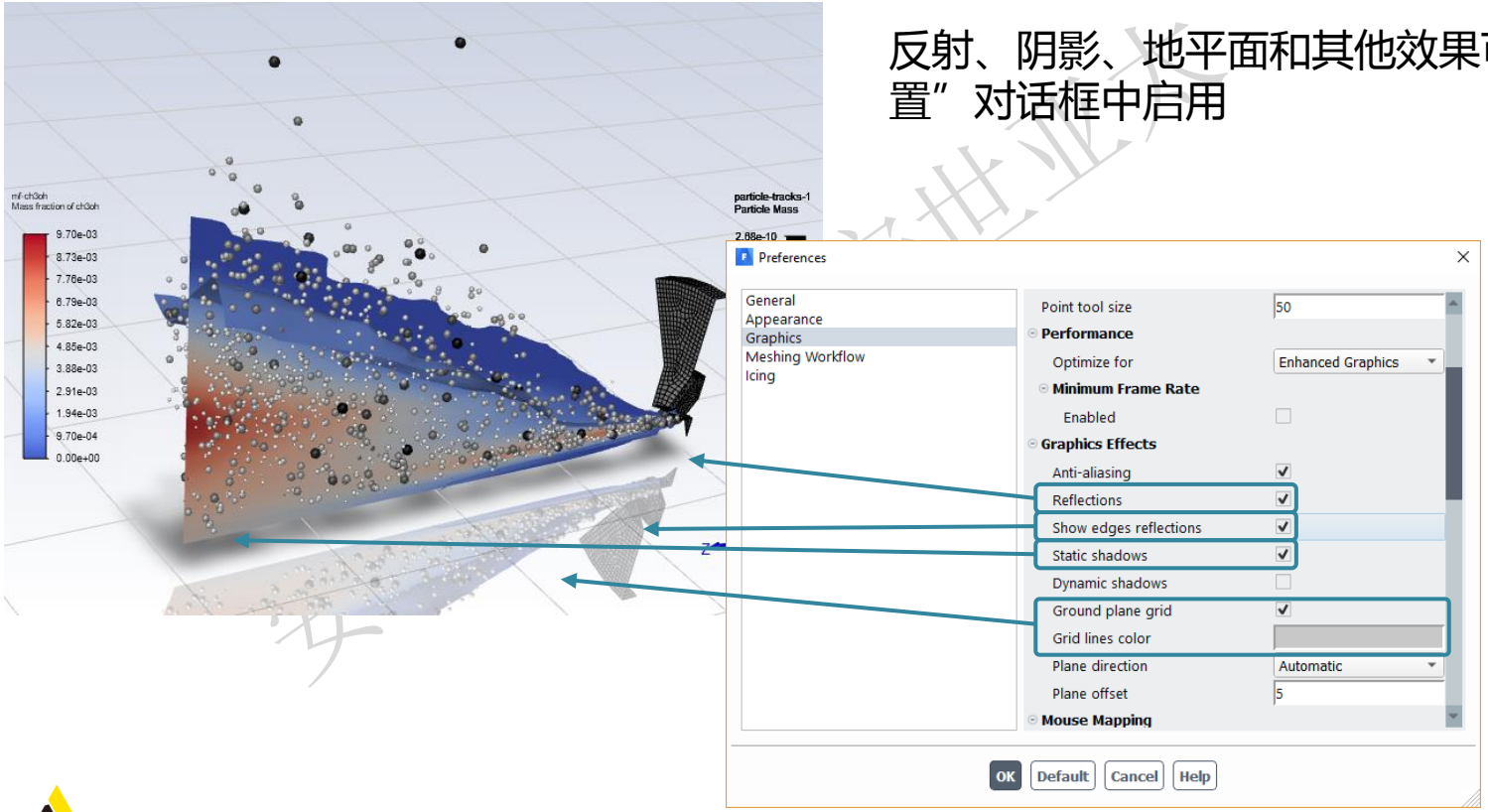
# 新的渲染效果

反射、阴影、地平面和其他效果可以在“设置”对话框中启用





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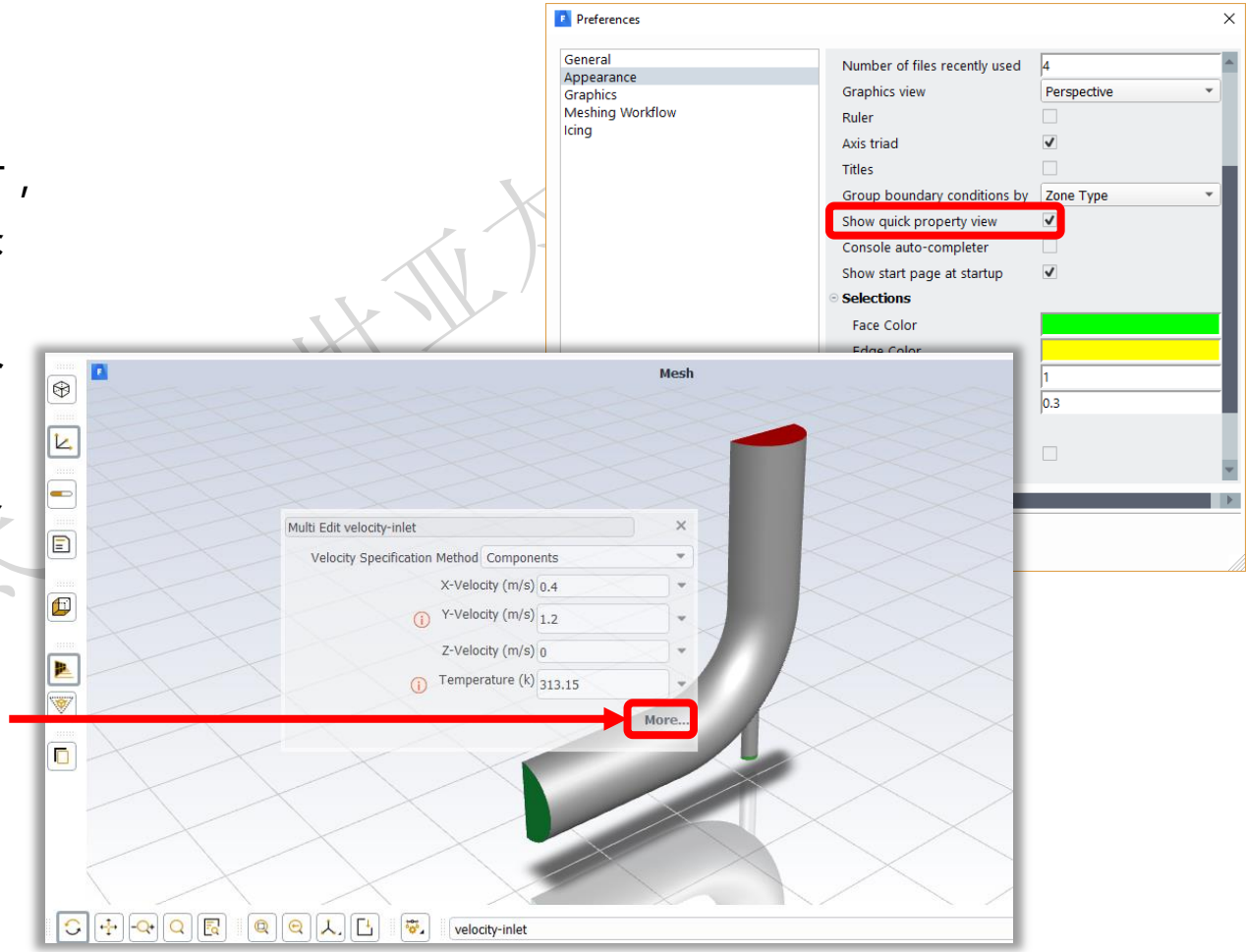
# 常用设置的沉浸式设置

- 当您在图形窗口中选择区域时，将出现一个带有最常见边界条件的快速菜单
- 利用多编辑功能轻松配置多个边界
- 点击**More...** 打开完整的边界条件对话框

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# Fluent 2020R1

## 流体新功能—物理模型增强


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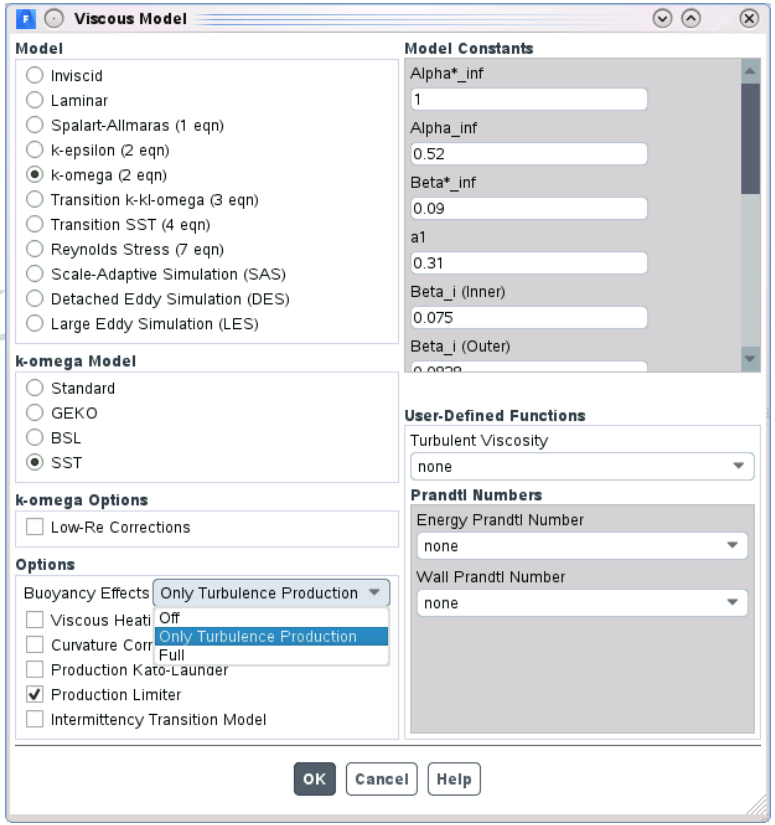
# 湍流模型: RANS

- **粘性模型的默认更改:**
  - 从层流切换为湍流
  - 默认湍流模型: SST
- **浮力作用:**
  - 新增基于 ω的模型
    (基于ε的模型已经发布很久)
  - 基于ε和ω模型的GUI/TUI 整合





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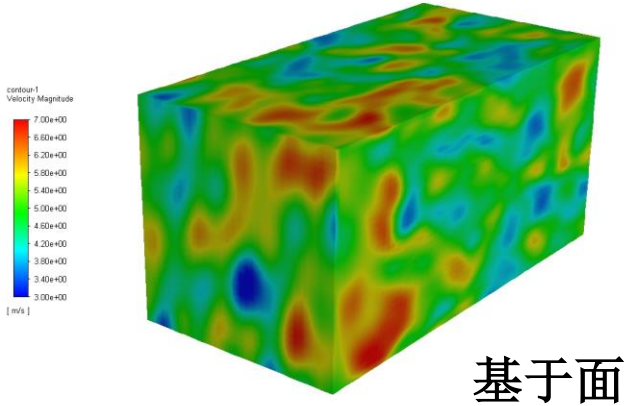
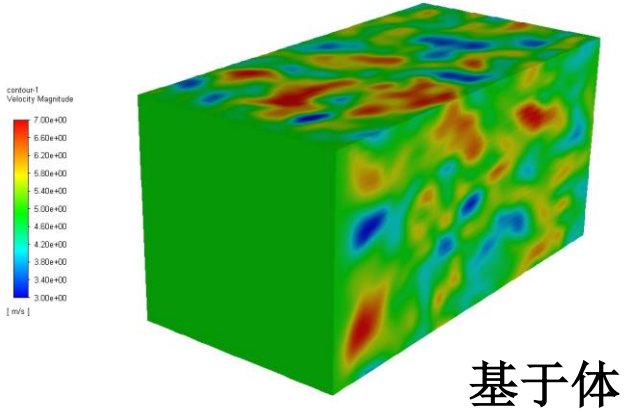
# 湍流模型: SRS

■ **体合成湍流(Volumetric synthetic turbulence)：**

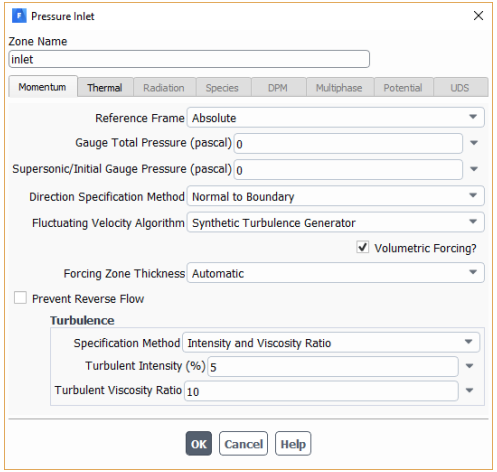
- 无噪声合成湍流发生器，适用于声学应用
- 速度快，即使是并行的
- 注:仅适用于SBES模型，未来版本有进一步改进




基于面




基于体

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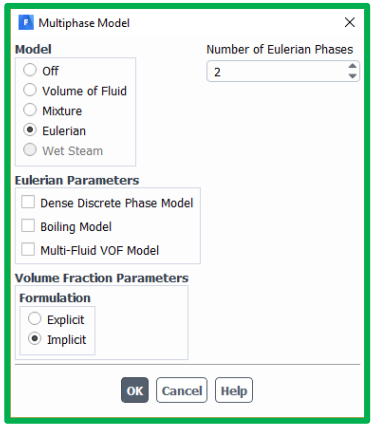
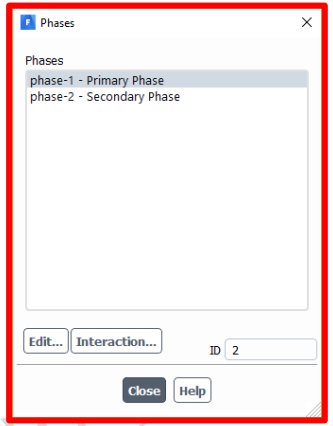
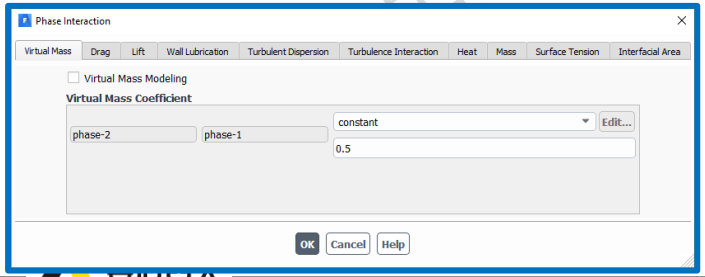
# 欧拉多相流: 工作流程整合

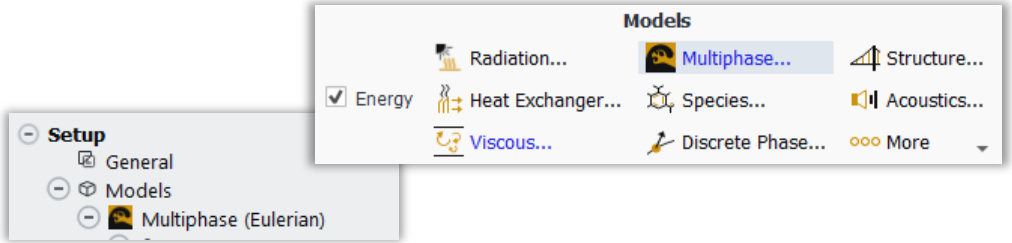



2019 R3




- 以前，设置多相流问题需要访问多个不同的对话框
  - 顶层模型设置
  - 相定义
  - 相作用 (动量, 热, 质量交换等)
- 2020R1合并为一个可以从Ribbon或Outline视图中访问的对话框





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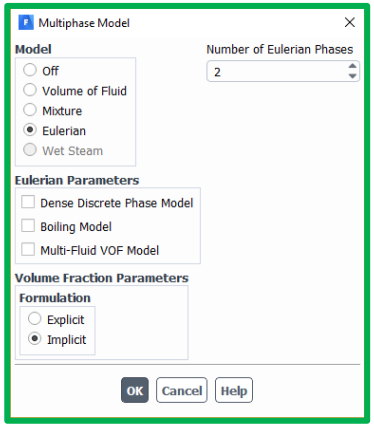
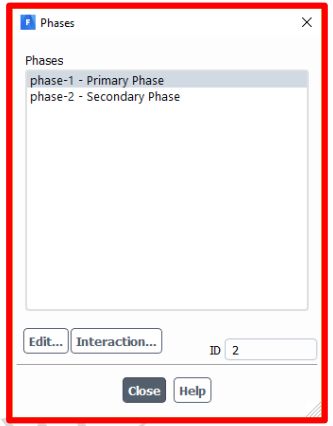
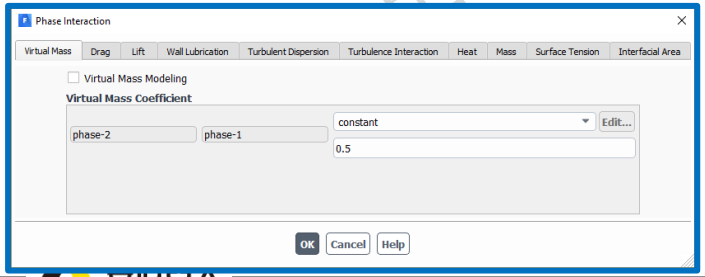
# 欧拉多相流: 工作流程整合(模型)

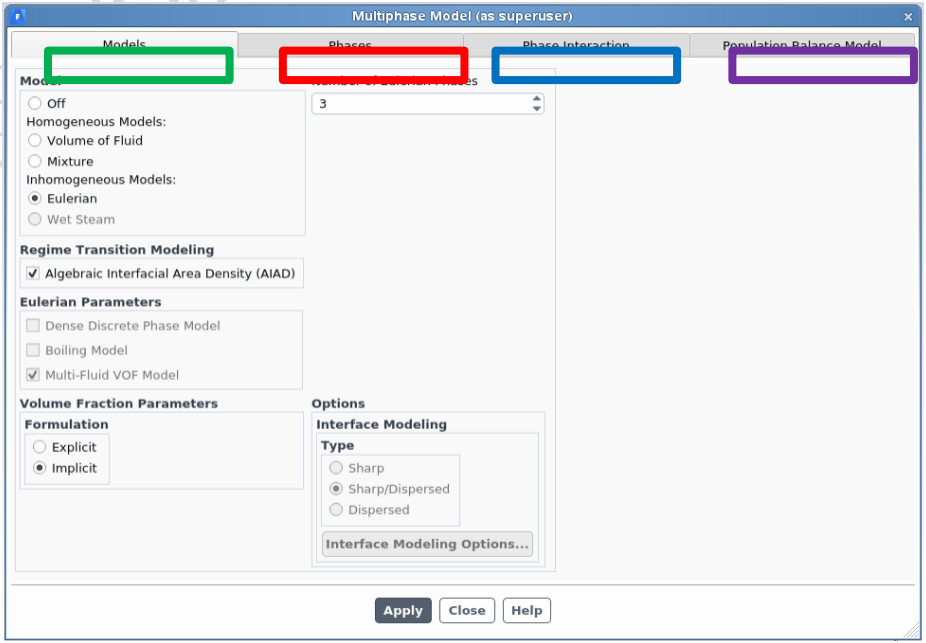
2019 R3




2020 R1





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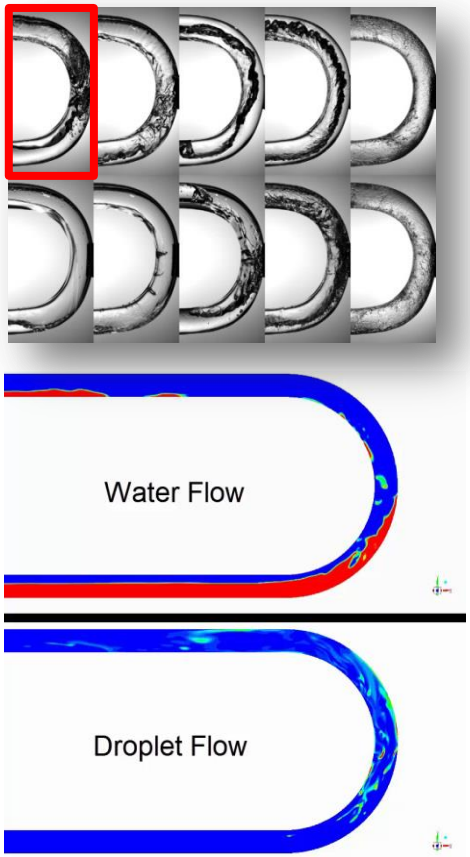
# 欧拉多相流: 流态转变(Regime Transition)

- 基于代数界面面密度方法
- 通过以下方式提供更准确的结果:
  - ✓ 包含亚格子湍流贡献
  - ✓ 包含考虑卷吸/吸附效应的质量传输机理
- 群数平衡可以模拟稀疏相的尺寸分布
- 适用于包括压水堆冷却剂损耗在内的一系列应用场合

Barbosa et al.




Water : 0.05 m/s (superficial Velocity)
Air: 1m/sec

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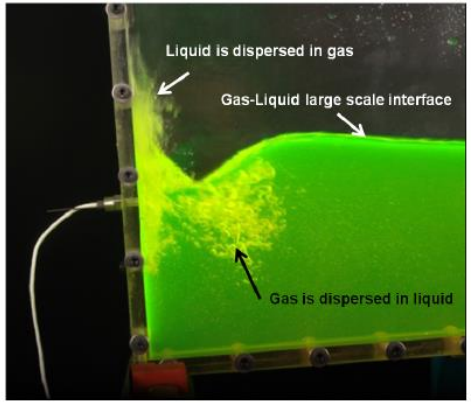
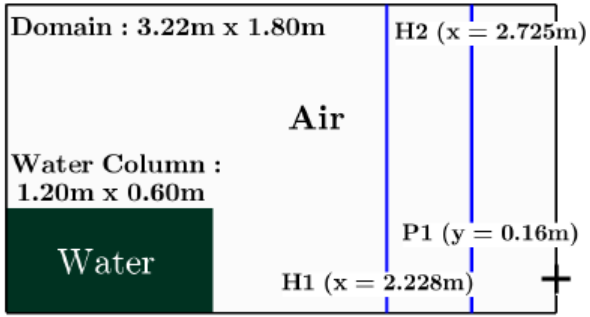
# 欧拉多相流: 流态转变(溃坝试验案例)

- 溃坝案例来自于Zhou et al. (1999)
- ✓ 与发表的LSI模型结果进行比较: Ghada, Elias, Tando and Lo (2015), on “A Large Scale Interface Multifluid model for Simulating Multiphase Flows”.
- 使用AIAD方法在FLUENT中对相同的条件进行了模拟
- 均匀网格 144 x 80.




液体在腔内晃动时，同时存在小尺度和大尺度界面
*(Souto-Iglesias et al., 2011).*




溃坝模拟的初始条件和不同的探测位置
*(Zhou et al., 1999).*

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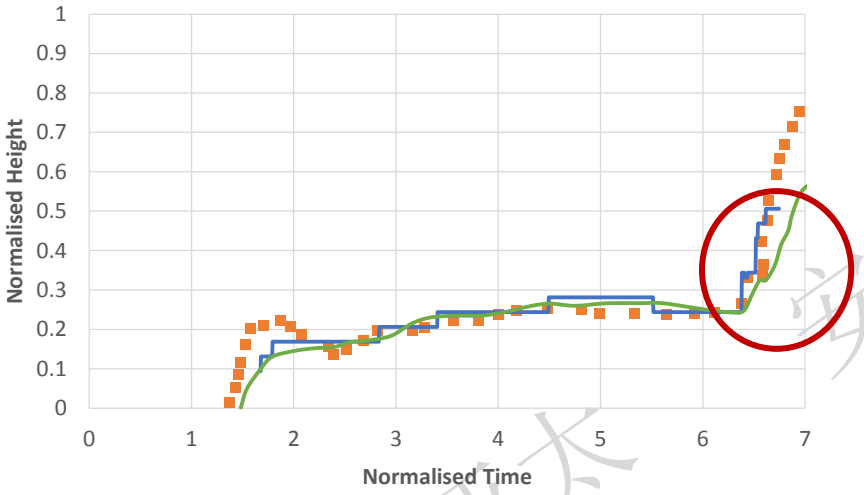
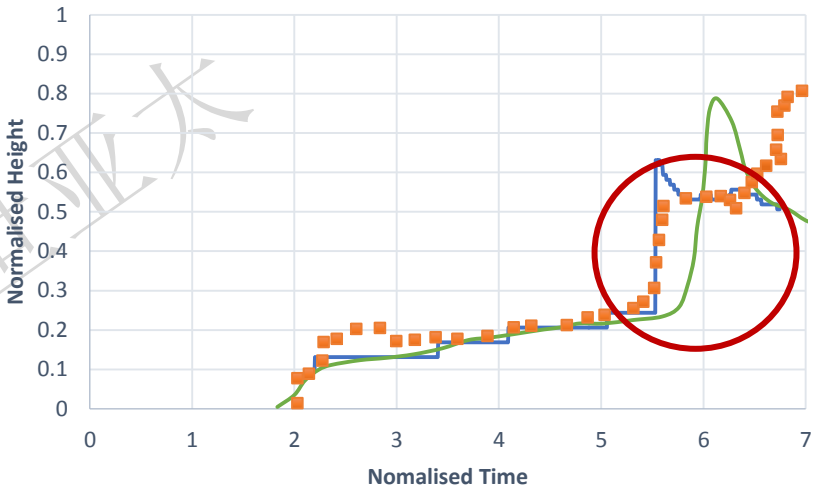
# 欧拉多相流: 流态转变(溃坝试验案例结果)




H1(左)和H2(右)界面高度时间变化

实验数据

FLUENT AIAD

LSI method

Fluent AIAD在两个采样点都能更好地匹配实验结果



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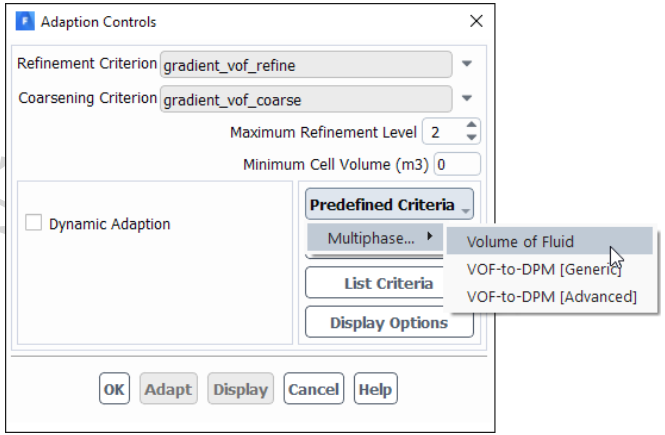
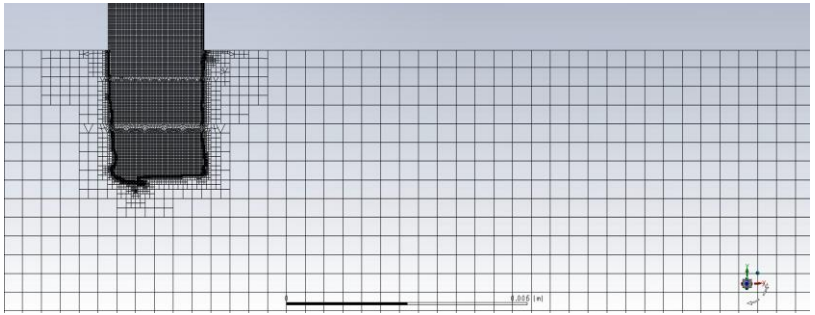
# VOF 增强

- 针对VOF和VOF-to-DPM 模拟的预定义网格适应标准
  - VOF和VOF-to- dpm模拟受益于基于解的网格适应
  - 适当的标准可能很复杂
  - 预定义的标准会用最少的用户输入自动配置适应规则

    **Volume of Fluid**: 基于体积分数梯度
    **VOF-to-DPM [Generic]**: 基于接近VOF界面的程度
    **VOF-to-DPM [Advanced]:** 基于接近VOF界面的程度和交界面以及次要相区域内部的网格尺度阈值
- 针对稳健VOF模拟优化的新数值设置



使用VOF-to-DPM [Advanced]的网格适应: 注意交界面和液体内部不同的网格加密程度

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# 多相流鲁棒性增强

- 对于浮力驱动的多相流，您现在可以使用以下新方法模拟操作密度：
  - minimum-phase-averaged (缺省设置，适用于绝大部分工况)
  - primary-phase-averaged
  - mixture-averaged
  - user-input
- 通过新的默认值和设置来优化计算的稳定性

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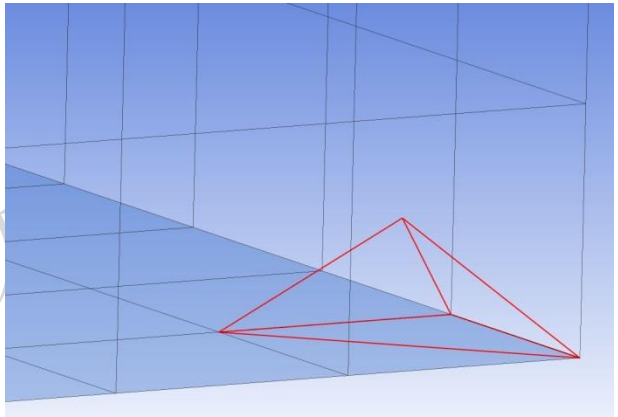
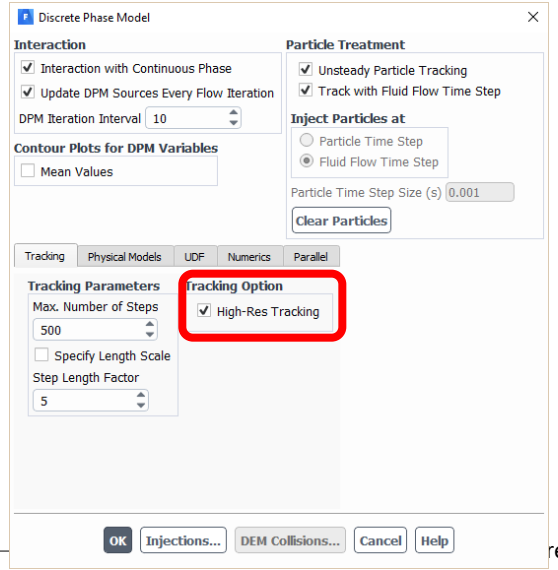
# DPM: 高精度跟踪

- 新的粒子跟踪方法提供了改进的鲁棒性、插值和分区依赖性
  - 尤其对于小颗粒(i.e. 弛豫时间很短)
- 通过“subtets”跟踪粒子
  - 将网格分解成四面体 (subtets)
  - 通过subtets已知的连接性跟踪粒子
  - 连续插值流动计算结果
- 与大多数DPM功能兼容
- 例外:
  - 欧拉多相流 / 稠密离散相模型
  - 重叠网格
  - 运动和变形网格(MDM)
  - 离散元方法(DEM)



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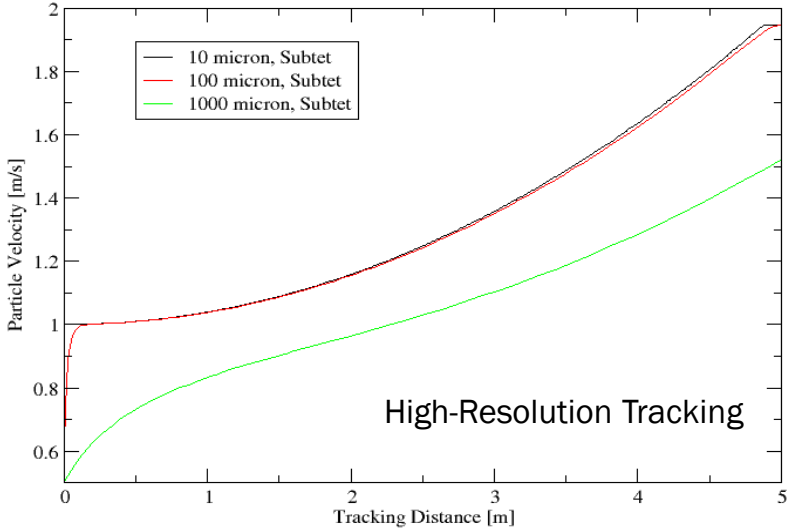
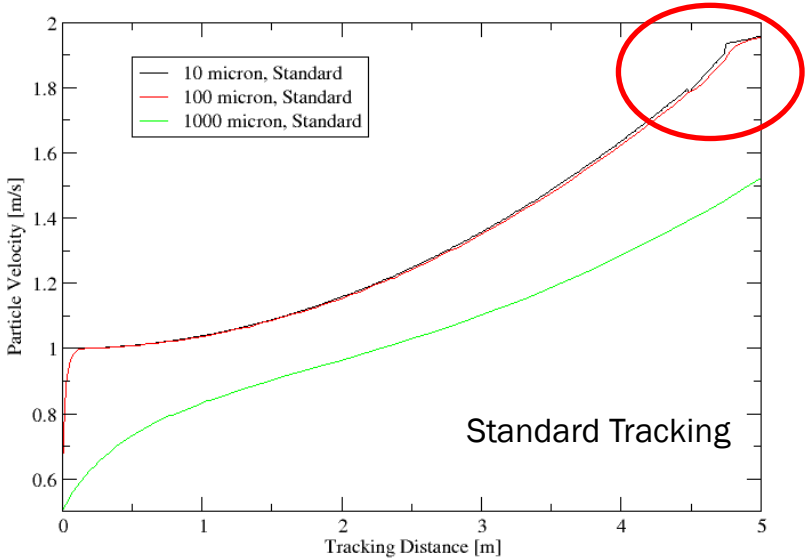
# DPM 高精度跟踪: 案例1

加速流中的粒子
- 六面体网格管道
- 跟踪方法比较




总结
- 对于大到中等大小的粒子，结果是相同的
- 小颗粒在速度上不再表现出非物理的扭曲
- 主要是由于连续流体流动计算结果的插值

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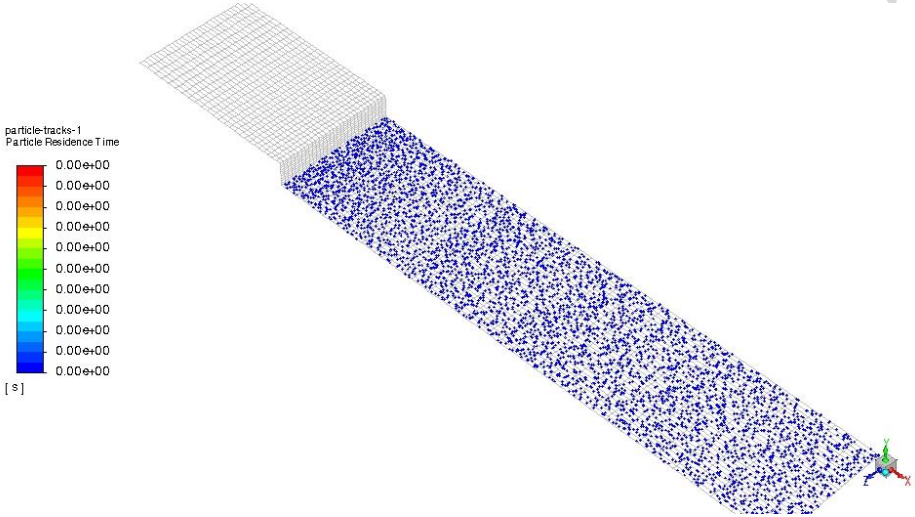
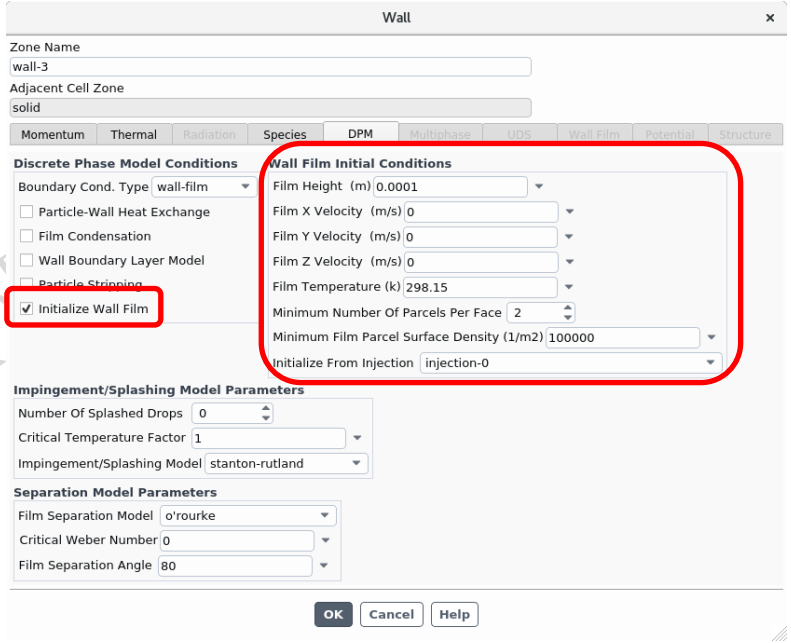
# 拉格朗日壁面液膜初始化

在wall对话框的DPM选项卡中**Initialize Wall Film** 选项(离散相模型条件组框)




- **设置的值**
  - 壁面液膜高度
  - 壁面液膜速度
  - 液膜温度(能量方程激活时)
  - 每个面的最小粒子包数
  - 最小液膜包数面密度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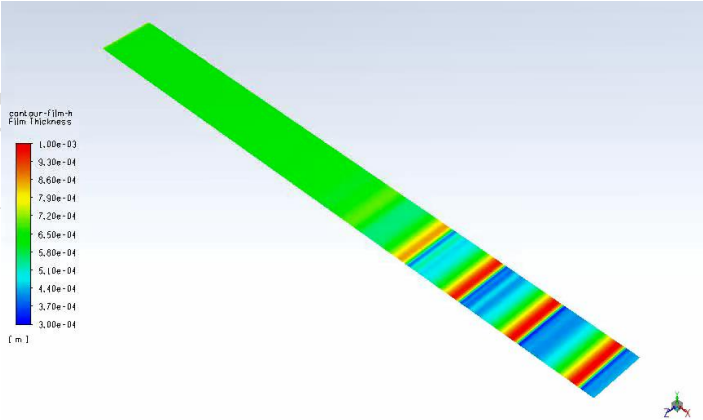
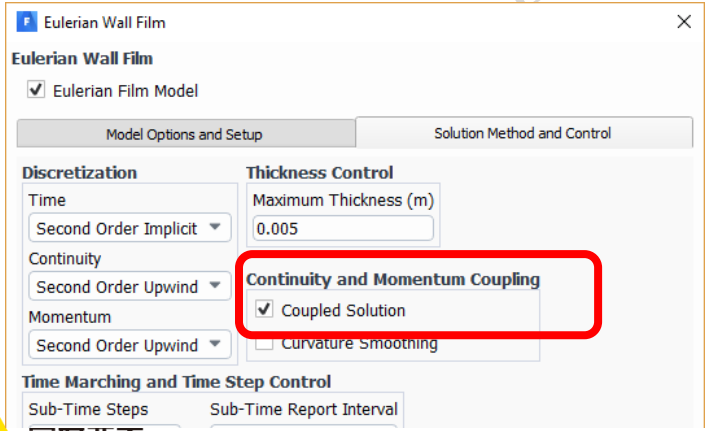
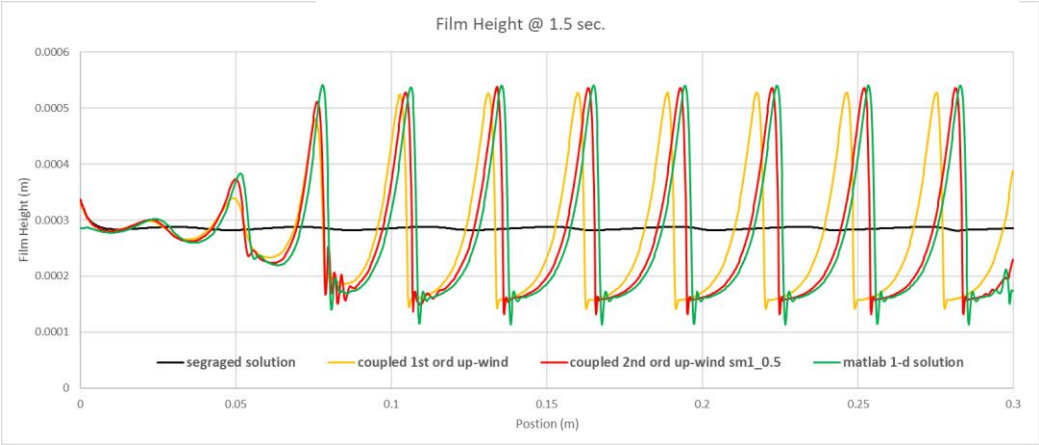
# 欧拉壁面液膜的耦合时间推进算法

- 在某些应用中(如重力驱动的下落膜)，膜的高度和动量是紧密耦合的。
- 在这种情况下，需要一种耦合的解决方案来充分捕获产生的膜动力学(如毛细管波)

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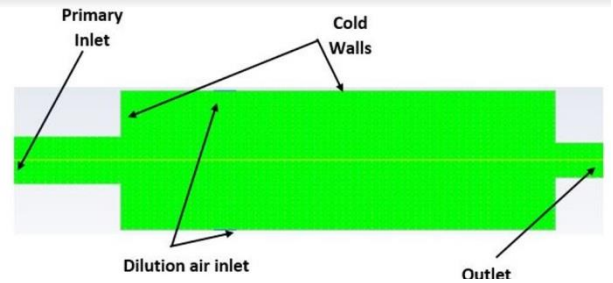
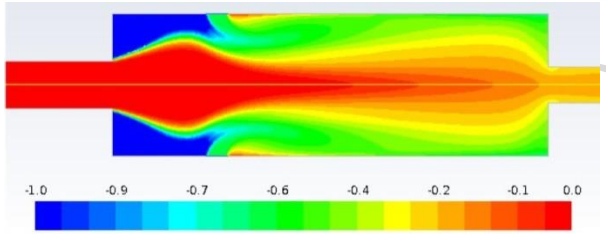
# 预混小火焰的非绝热FGM 模型

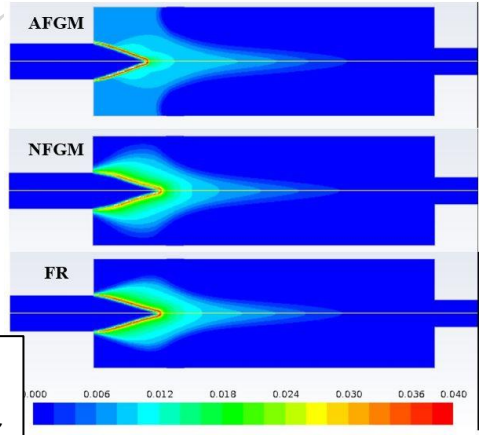
- 在由于冷壁、参与介质等的存在而导致热损失/增益不能忽略的情况下，提高计算精度
- 并行FGM小火焰和PDF创建



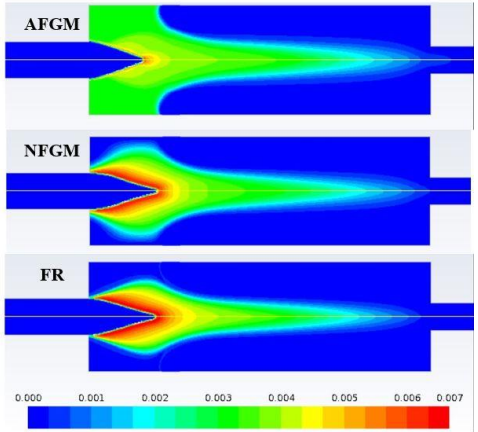

带有冷壁的部分预混的ch4 -空气火焰
=> 火焰稳定时存在高的热损耗




CO 质量分数




OH 质量分数




用有限速率解验证了FGM结果

非绝热FGM (NFGM)预测了组分对热损失的敏感性

基于绝热小火焰(AGM)的FGM不能捕捉热损失对组分预测的影响

AFGM : FGM based on adiabatic Flamelets

NFGM : FGM based on non-adiabatic Flamelets

FR : Finite Rate Chemistry Solution

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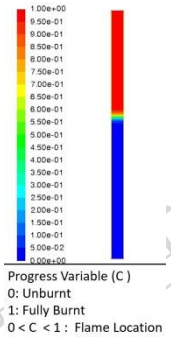
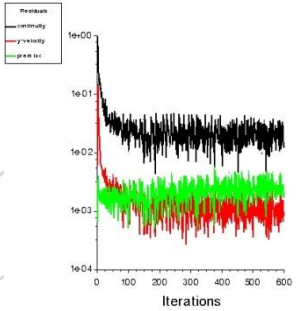
# FGM有限速率鲁棒性和收敛性改善

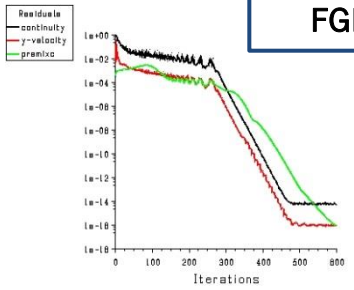
- 对于瞬态FGM有限反应速率粒子，默认使用新的更稳定的数值方法

改进的
FGM

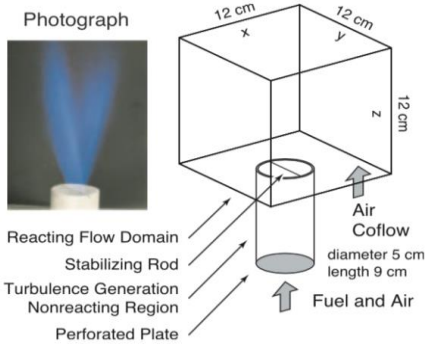
**一维高压自由传播预混火焰**



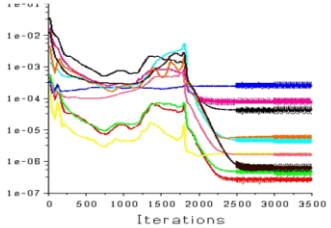



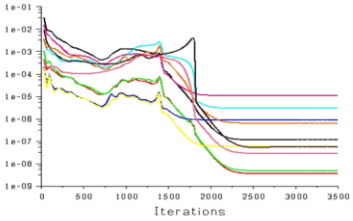



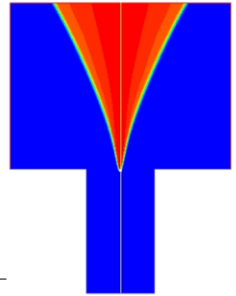

**湍流预混V火焰**

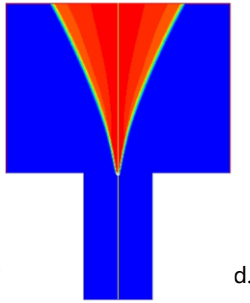



Schematic of the case: Flame stabilized on a rod



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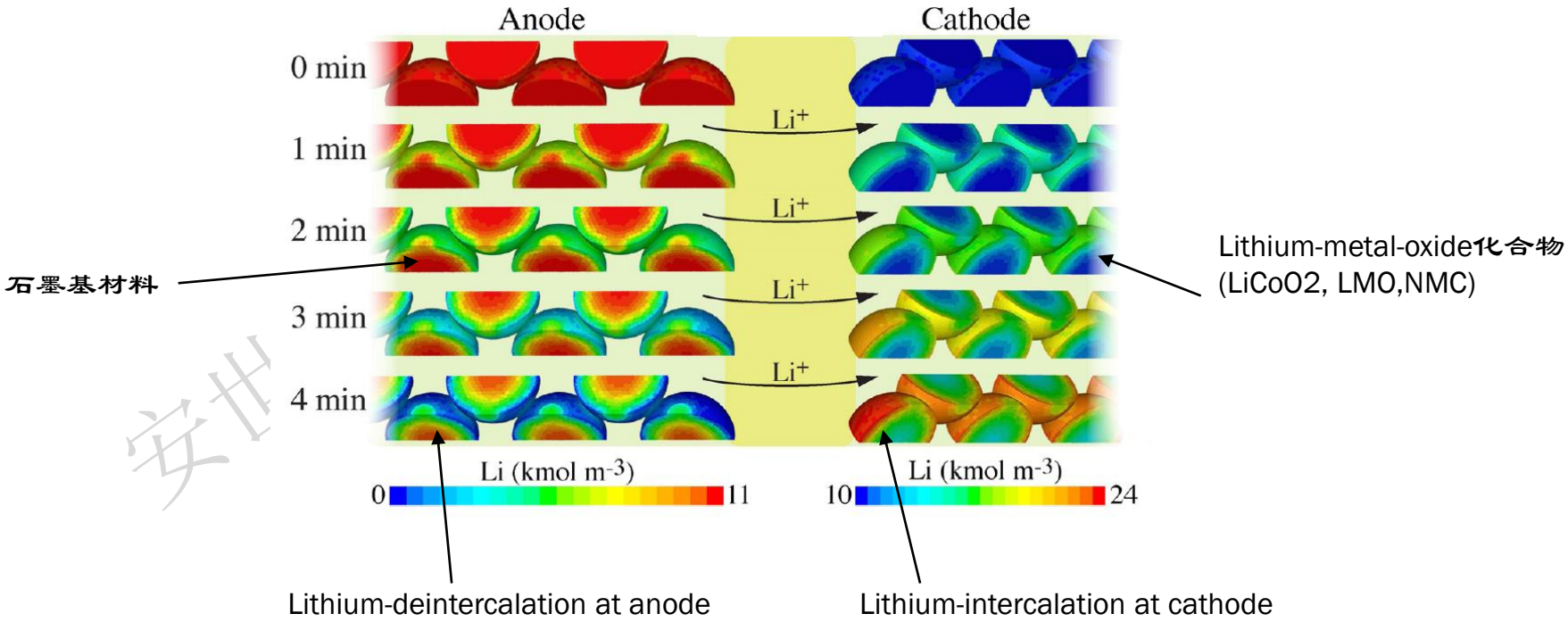
# 锂离子的详细三维电化学模拟

- 目标用户: 电池和材料厂商
- 锂离子放电/充电过程的瞬态模拟





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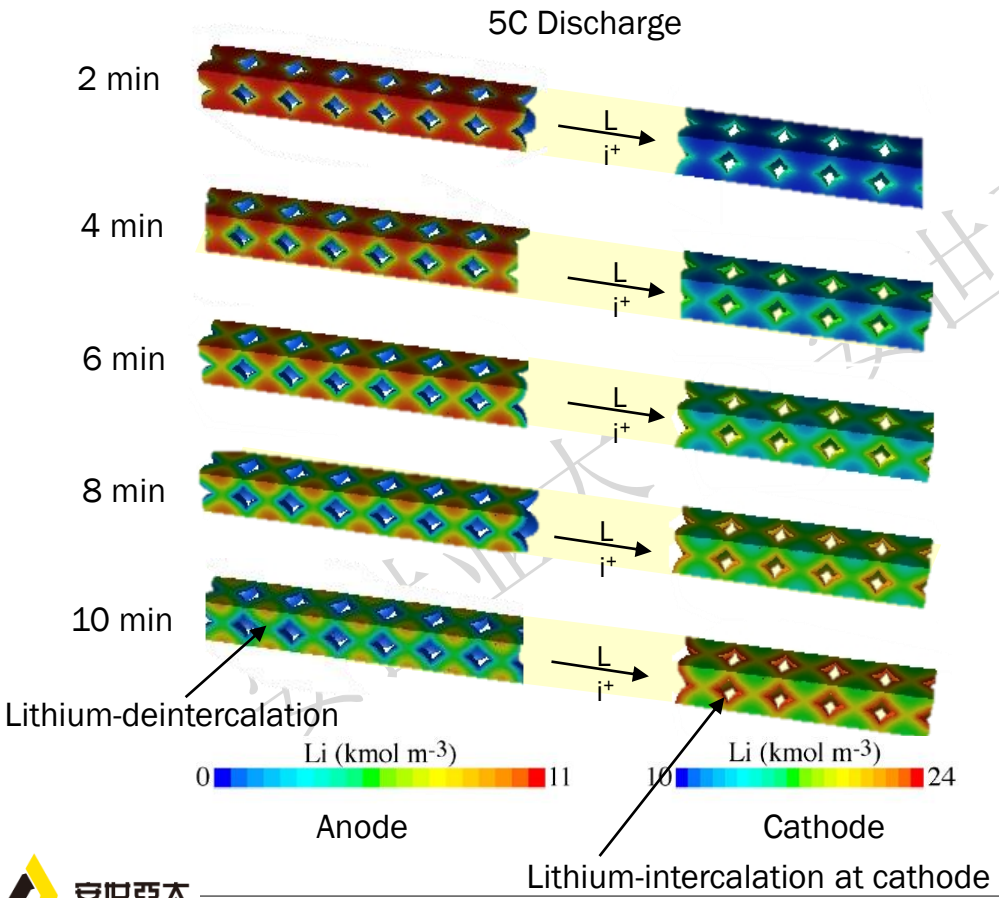
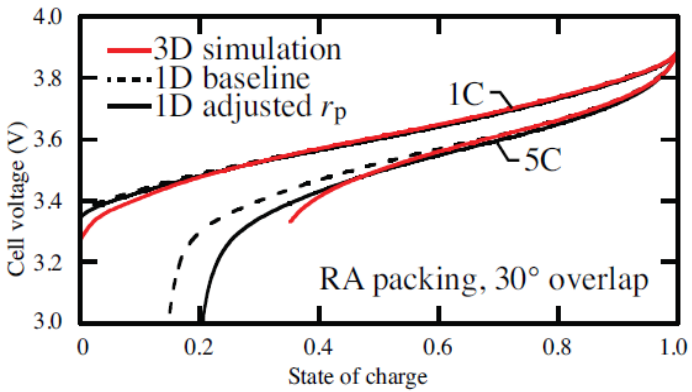
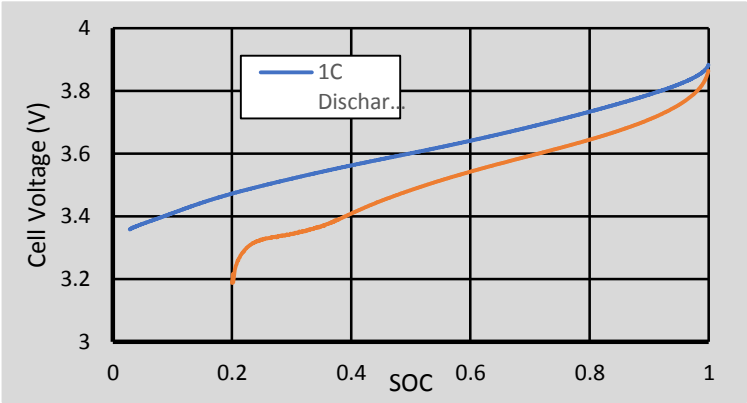
# 3D 电化学案例




- 电池电压在1C和5C放电速率
- 5C放电时，电极内Li浓度的等值线图

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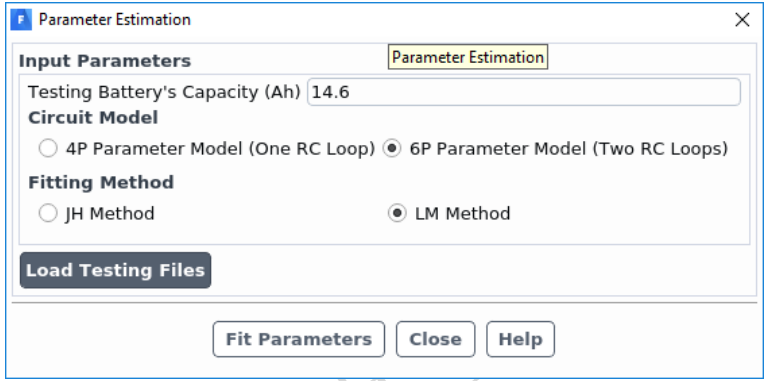
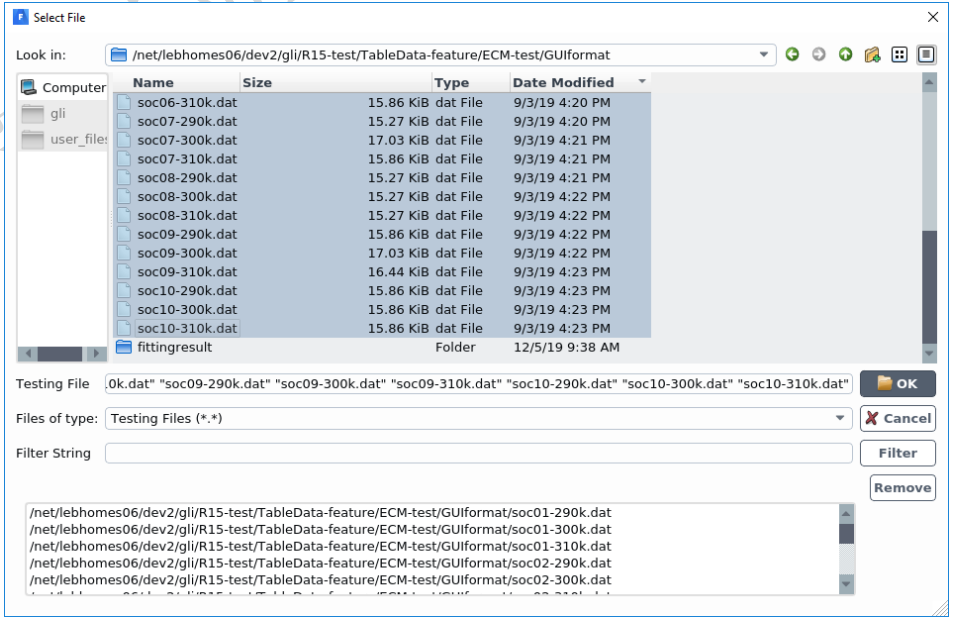
# 基于GUI的NTGK和ECM参数估计工具

- 等效电路法(ECM)和NTGK方法依赖于参数，这些参数通常由Fluent中的参数估计工具确定。
- 参数估计工具现在有一个GUI前端,用于加载文件和计算参数。





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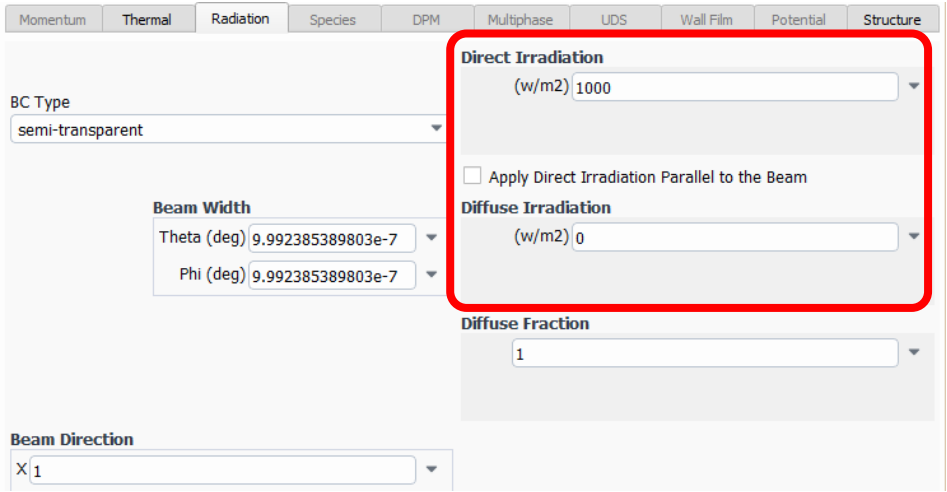
# 热辐射

- 对于蒙特卡洛模型定义漫射和直射边界源
- 对于DO 和蒙特卡洛模型，自动计算源的方向
  - 取消选择**Apply Direction Irradiation Parallel to the Beam** ，将指定的直接照射理解为垂直于边界

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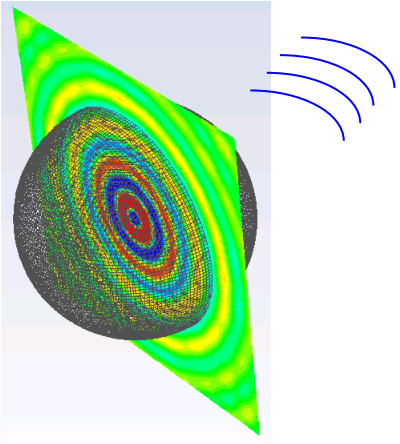
# 声波方程求解的基尔霍夫积分方法



- 声传播到远场的积分法
- 可以使用任何封闭面作为积分面(不只是区域表面，如FW-H)

注意:

- **Moving Receivers**选项只支持FW-H模型。如果使用基尔霍夫模型，则忽略**Moving Receivers的**输入。
- 目前基尔霍夫积分方法只支持 “on-the-fly” 计算。

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# 结构模型增强

- 非线性弹性
  - 考虑了影响刚度矩阵的固体大变形。
- 兼容楔形和金字塔网格
- 冯米塞斯等效应力现在可以作为一个后处理量

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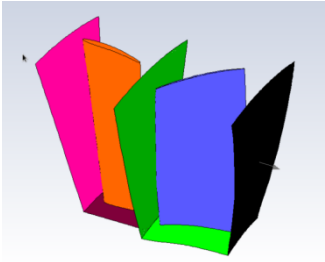
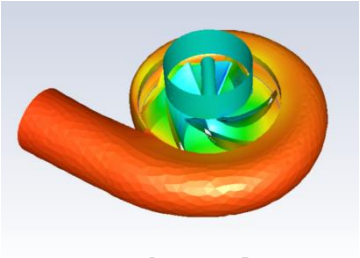
# 旋转机械

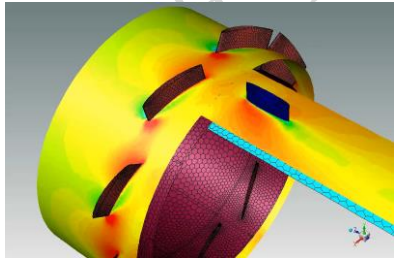
- **通用涡轮界面(GTI) *基本的叶片排交互模型**
  - 创建涡轮界面的统一位置
  - 稳态: Frozen Rotor w/ pitch-change & Mixing-Plane模型
  - 瞬态: TRS w/ pitch-change



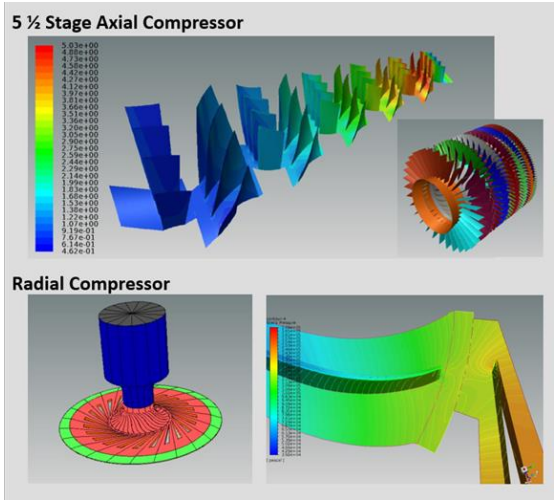
Sector-to-sector

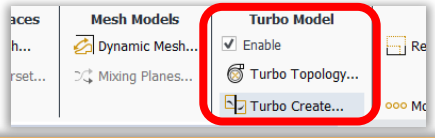


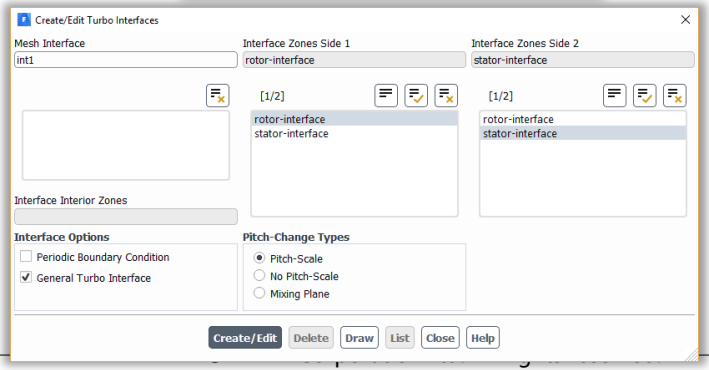
360-to-360



Sector-to-360




- **Ribbon中的涡轮模型**
  - 涡轮工作流程：启用涡轮模型和通过快捷方式来创建GTI
- **边界条件增强**
  - 在压力进口和出口位置阻止回流

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# Fluent 2020R1

## 流体新功能—求解器增强


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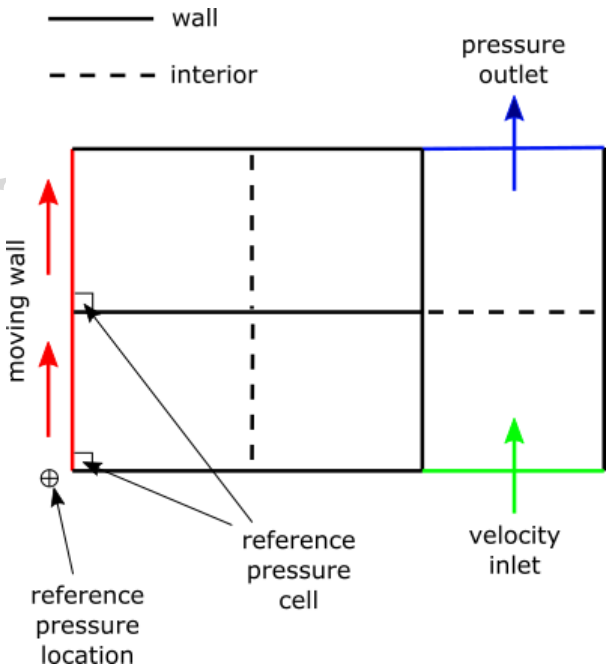
# 数值方法: 多参考压力

- 参考压力用于防止表压力在无压力边界的不可压缩流动中浮动
- 对于不连通的流体区域，最好分别对每个区域施加参考压力
  - E.g.一个计算域可能有压力边界，而另一个计算域则没有。采用多参考压力法在无压力条件下的区域内使用参考压力.




Console

```
> /define/operating-conditions/reference-pressure-method
Options:
 1. Connected fluid zones only
 2. Connected and disconnected fluid zones

Enter selection [1] 2

 Reference pressure method for both connected and disconnected fluid zones will be applied.

>
```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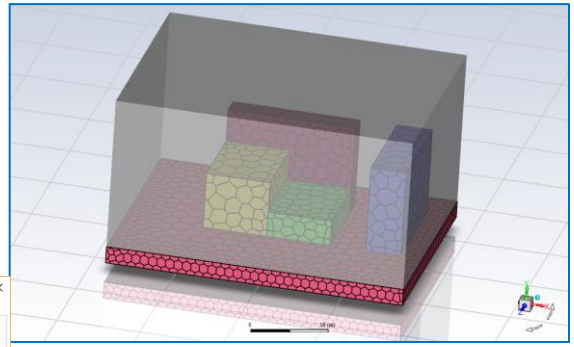
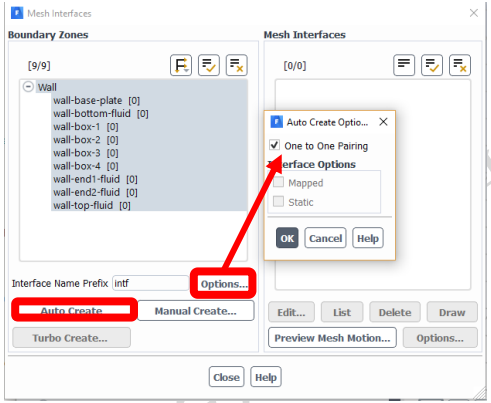
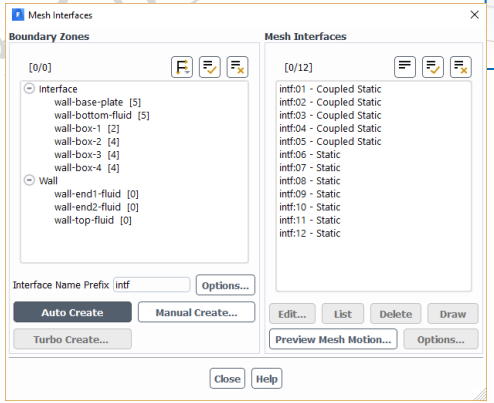
# 一对一自动交界面配对

- 自动检测和创建体之间的一对一连接对
- 体面可以有多个相邻体；在网格划分时不需要对面进行分割
- 在所选的壁面和交界面上实施






TUI: /define/mesh-interfaces/auto-pairing-one-to-one

**注意：以这种方式创建的所有交界面都被视为静态的。一对一自动配对不支持映射选项。**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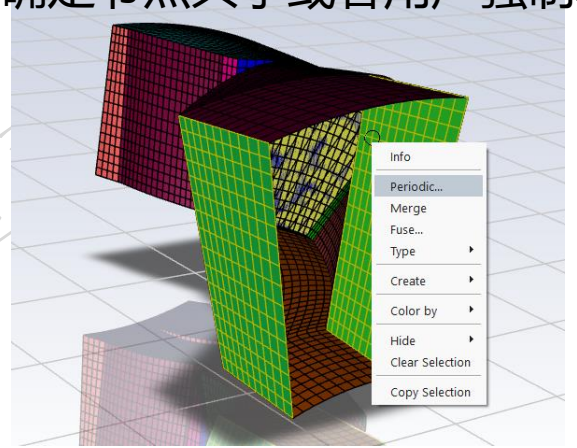
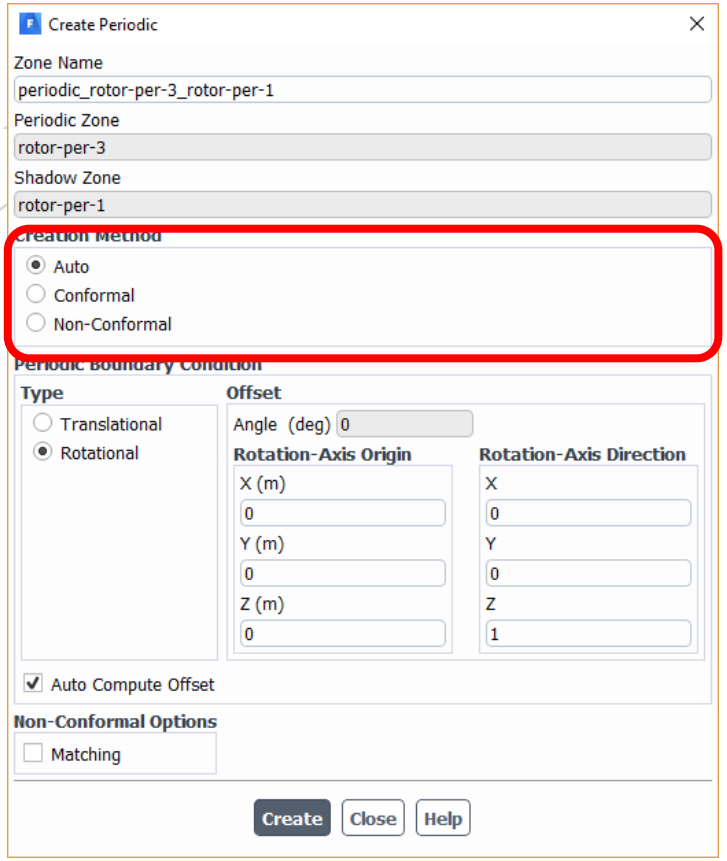
# 基于GUI的通用周期性边界创建

- 选择任意两个边界域(在大纲视图或图形窗口中)
- 右击选择**Periodic...**
- 与创建节点共享和节点不共享周期性边界的流程一样
- Fluent 可以自动确定节点共享或者用户强制输入





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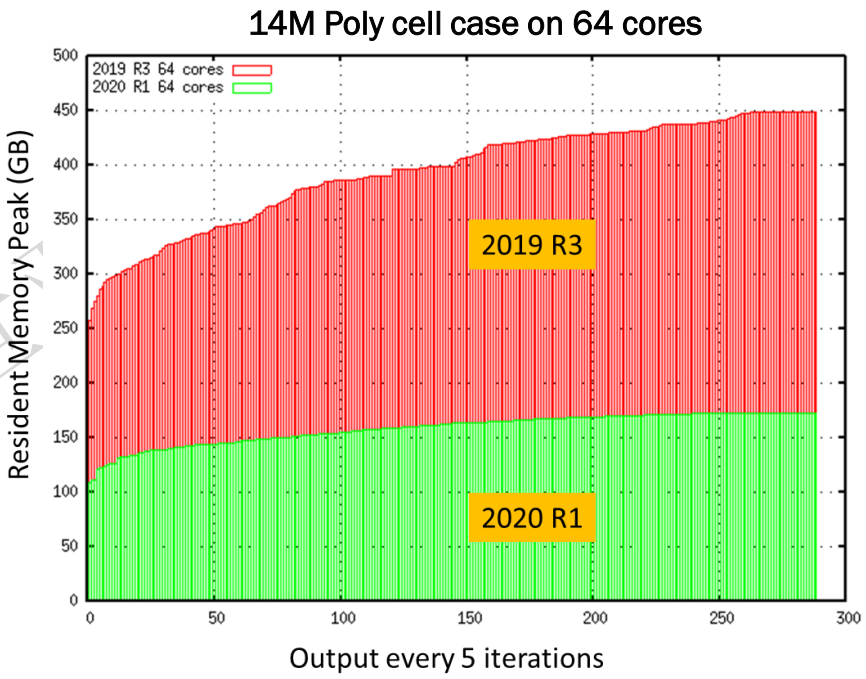
# 重叠网格增强

- 采用新的单元交换模型，提高了并行存储效率
- 限制较少的NCI（Non-conformal interfaces ）兼容性检查
  - 假如NCI和overset区域不重叠，可同时使用NCI和overset
- 支持湍流转捩模型
  - Transition SST
  - Intermittency Transition
  - Transition k-kl-omega

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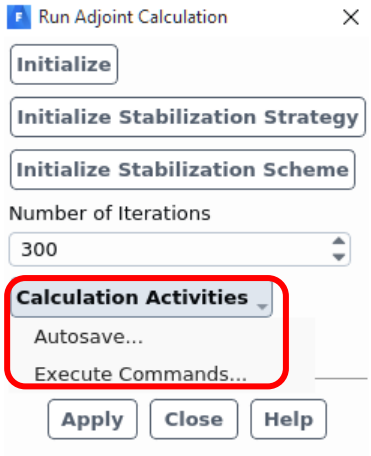
# Adjoint Solver

- 使用增强
  - 在计算期间支持“Autosave”cas/dat文件
  - 在计算期间支持“Execute command”

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# Fluent 2020R1

## 流体新功能—图形 / 后处理

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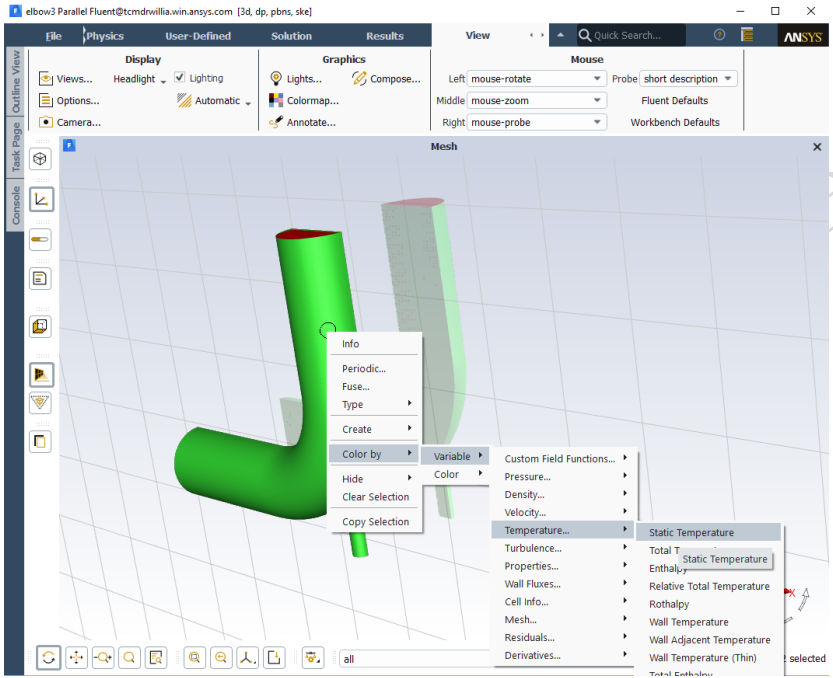
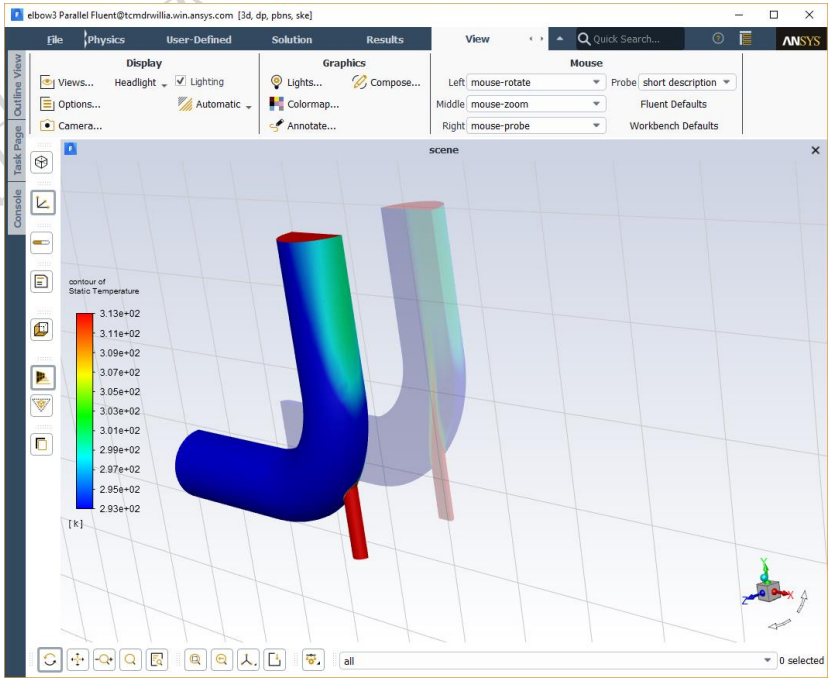
# 云图和颜色快捷键

- 右键选择面，通过**Color By** 选择场变量着色

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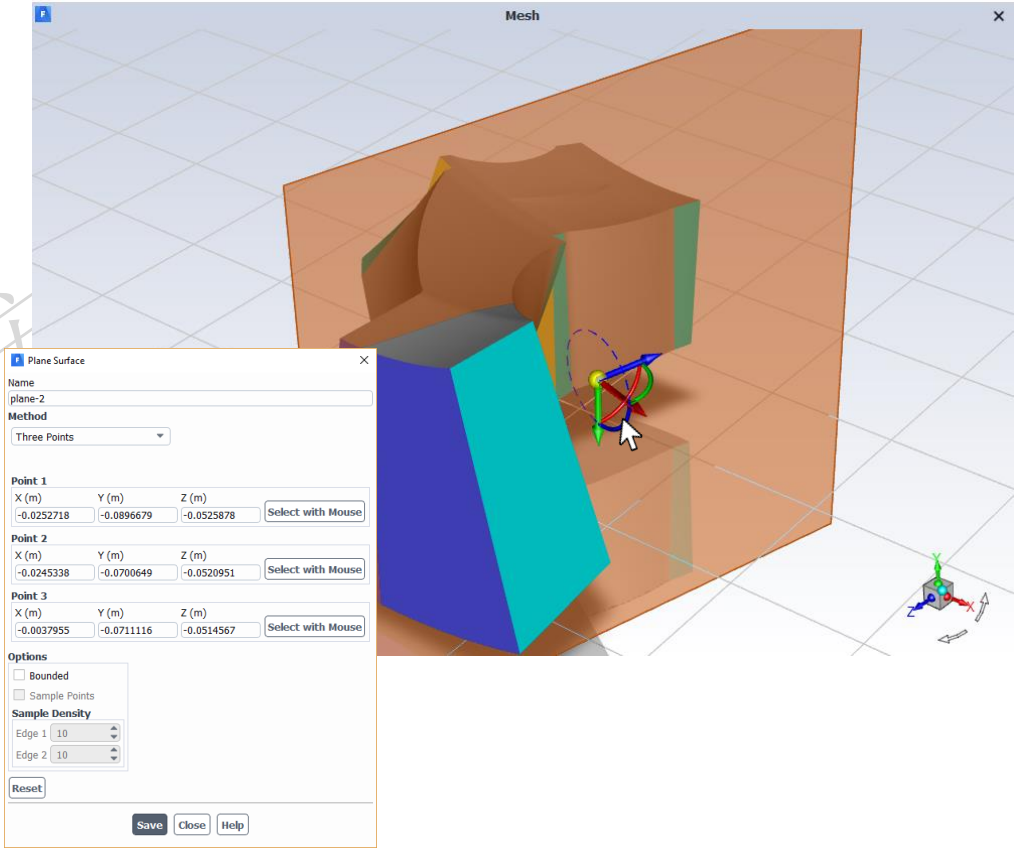
# 新的交互式平面创建方法

- 新的平面工具添加到所有的平面创建方法中

- 增强
  - 更加直观的处理方式
  - 沿着轴或象限拖动来执行受约束的平动/转动
  - 拖动原点可自由移动
  - 在操作期间动态更新显示

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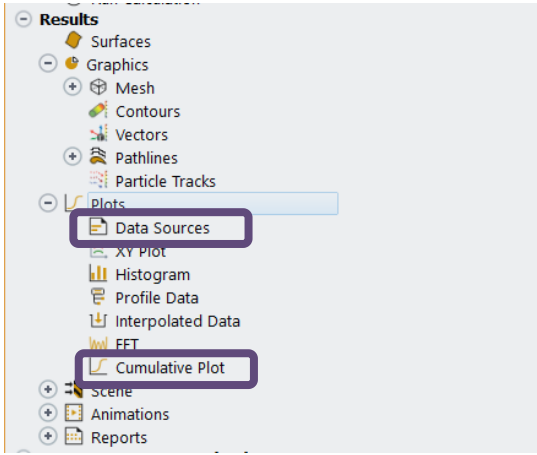
# 新图表类型




- **数据源（Data Sources）**
  - 合并来自XY图、报告图、外部数据文件等的数据
  - 支持多列数据和具有多个数据节的文件
- **累计图（Cumulative Plot）**
  - 绘制沿着指定轴的累积力/力矩数据

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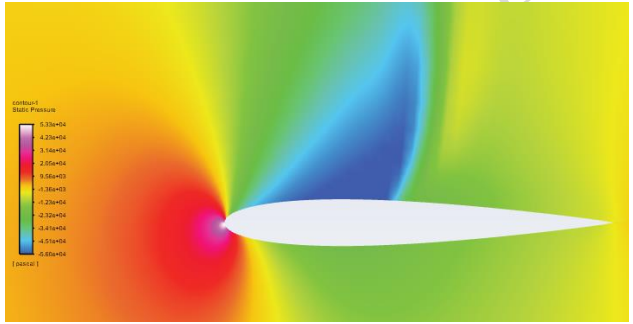

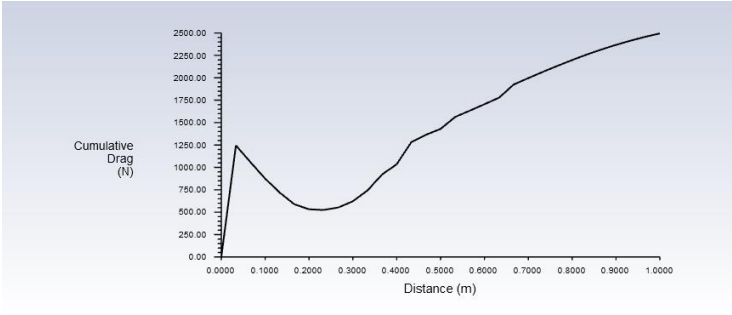



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# Fluent 2020R1

## 流体新功能—版本变更考虑

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# 弃用通知

- 不再支持从启动模式运行–t0 模式 (或者 –tm0 网格模式)。命令行-t0 / -tm0在2020R1中仍然可用，但不受支持。
  - 在Fluent的未来版本中，-t0 tm0将被完全移除。
  - 请报告你使用-t1遇到的任何问题(启动界面中选择串行)
- CutCell 网格重构方法已被移除，不再能使用
- 由于安全问题，RSH不再用于生成远程Linux节点。请使用SSH 替代。
- 移除 **tpoly** 功能。如果您以前需要tpoly，您可以使用以下任何一种选择:
  - 将网格读入Fluent Meshing ，写出网格时激活 **Write As Polyhedra** 选项
  - 将网格读入Fluent 求解模式中，然后使用文本命令mesh/polyhedral/convert-hanging-nodes

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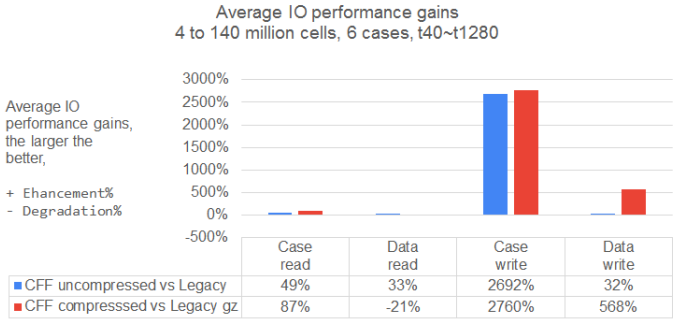
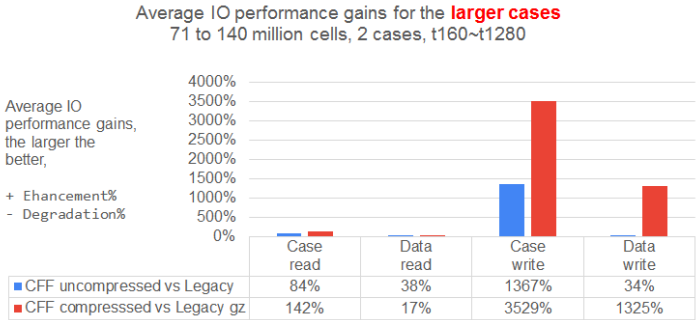
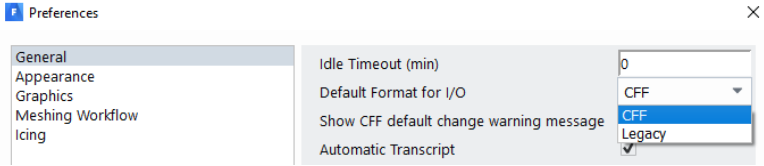
# 其它变更

- Case/Data 文件默认写成 *.cas.h5 / *.dat.h5 (CFF) 格式，可以提供更好的读写性能，尤其针对并行计算中的大case
  - 基准测试结果网格数为4M 到150M 之间，核数为 40 核-1280核
    - 写case要比先前的方式快10x 到20x
    - 读Case性能提高~50% - ~100%
    - 压缩文件的数据写入速度平均快5倍,未压缩文件快30%
    - 数据读取速度快~15% ~30%，但在小的压缩case下会有一些退化~20%




如果需要，可以将用户首选项还原为先前格式

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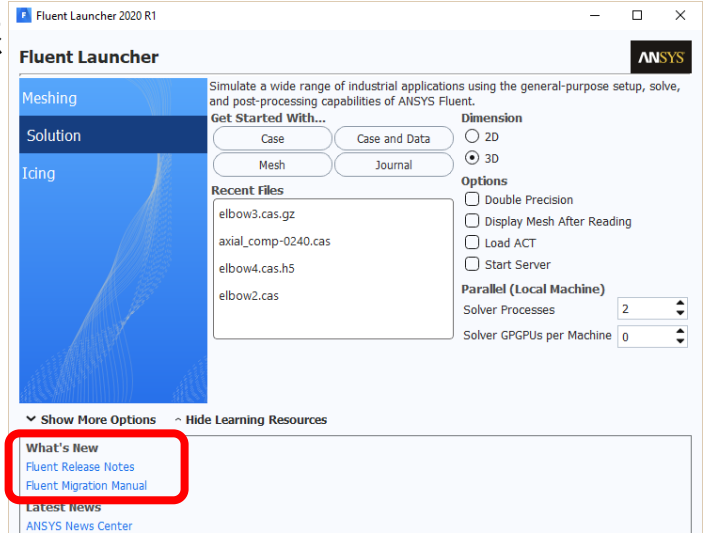
# 其它变更

- 粘性模型默认为kω-SST(之前是层流)
- 多面体非结构化网格适应(PUMA)现在在3D情况下默认使用。
- 在某些情况下，稳定性/性能增强和缺陷修正可能导致计算结果出现差异。
- 有关完整的细节，请参阅变更手册
  - 通过展开**Learning Resources**(需要internet连接)，您可以从启动程序访问发布说明和变更手册

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# Fluent 2020R1

## CFX 和涡轮工具亮点

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# TurboGrid / BladeEditor

## BladeEditor中增强的flank milling 线分布控制

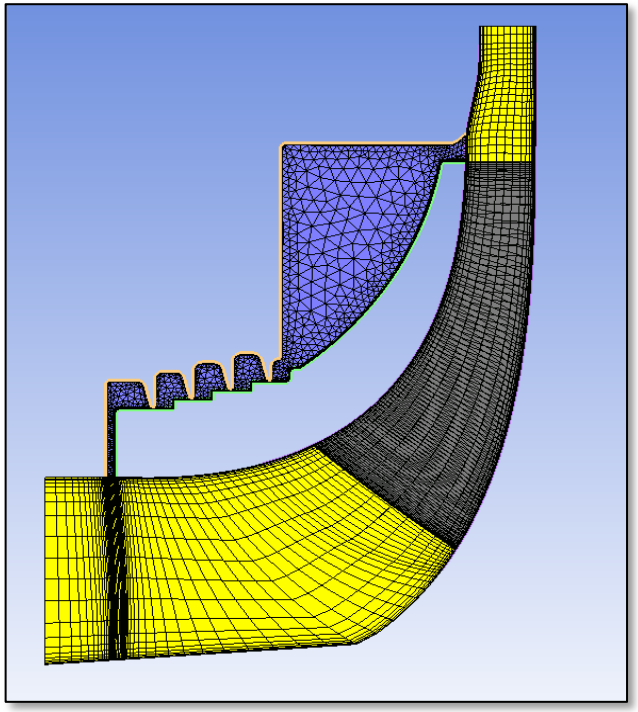
- Milling线的流向分布控制 (轮毂 vs 盖板)

## BladeEditor中其它变叶片混合控制

- 前缘及尾缘处的轮毂偏移跨度位置控制
- 支持NDF 文件

## TurboGrid中次要流道网格划分扩展

- 现在可以使用轮廓/坐标点定义主流道，而使用CAD曲线定义次要流道
  - 以前主要和次要流道都需要CAD



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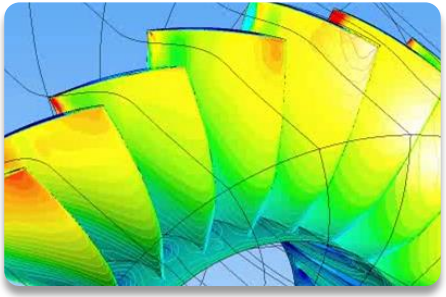
# 2 - 3倍的谐波分析加速

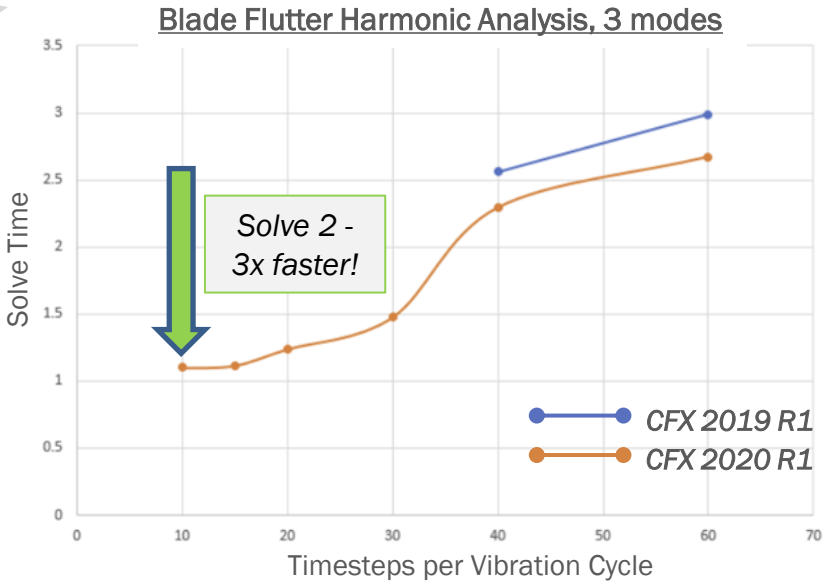
谐波分析(HA)利用谐波平衡法为瞬态周期流提供了快速的解决方案

- R18.0: Blade flutter (aerodamping)
- R19.0: Profile-Transformation, Frozen gust/inlet disturbance with Fourier-Transform pitch-change
- R19.1: CHT under Harmonic Analysis
- R19.2: Fourier-Transformation method

2020 R1提供了更大的性能改善

- HA计算比先前的快 2 – 3倍
  - 改进收敛性，特别是在求解许多次谐波时
  - 稳健的收敛性允许使用更大的为瞬态时间步长，极大的减少计算时间



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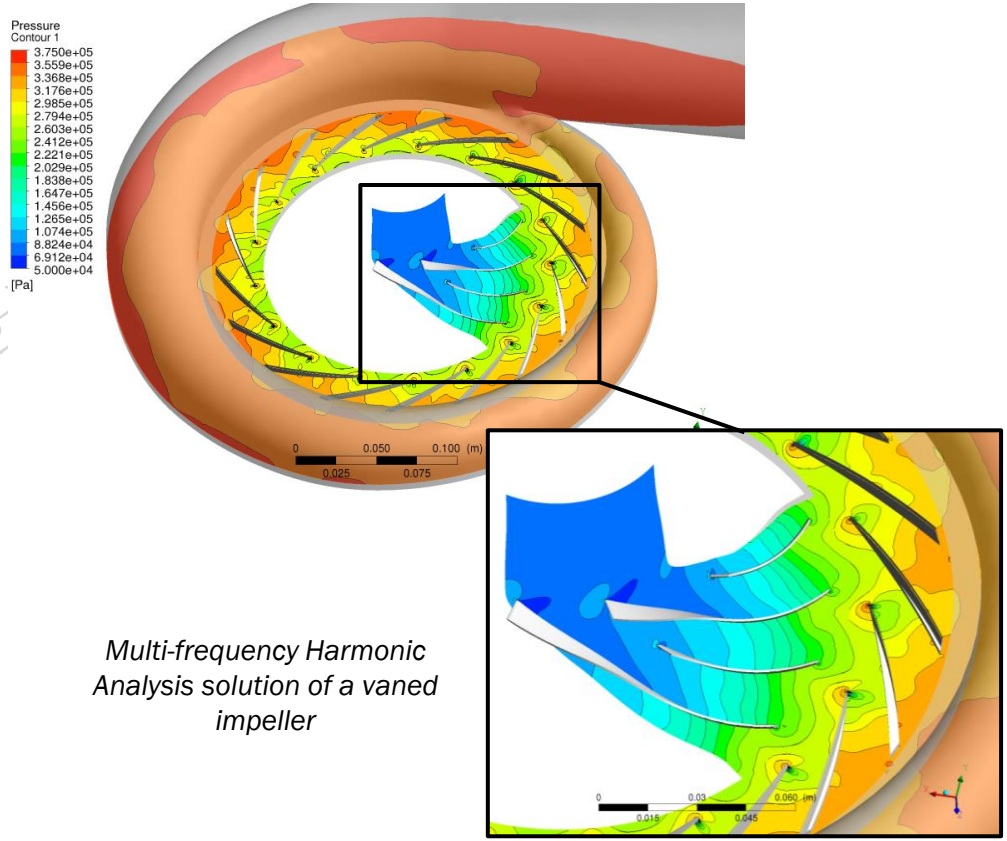
# 多频谐波分析

**CFX现在可以在谐波分析中求解多个基频**

应用:

- 多频入口扰动,
- 有叶蜗壳中的导叶
  - 两个基本频率 –一个用于叶片/叶片的相互作用，一个用于叶片和蜗壳作用




*Multi-frequency Harmonic Analysis solution of a vaned impeller*

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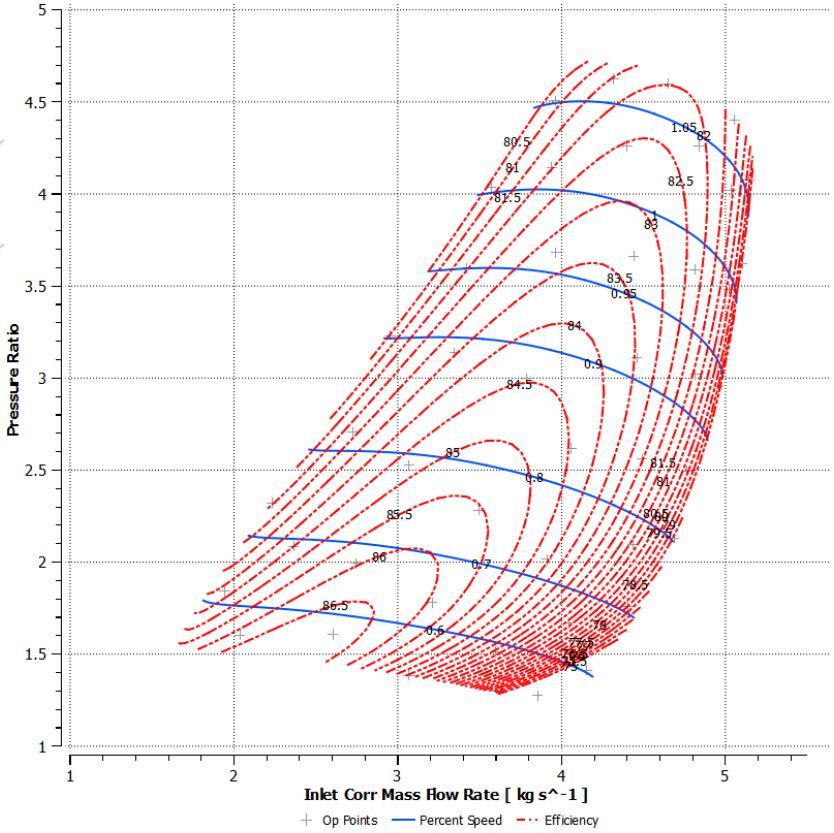
# 运行图

## 很容易将分析从单个工作点扩展到整个工作范围

- 性能图是分析结果
  - 管理类似从单个.mdef文件启动的单个运行，该文件生成多个运行
  - 在run文件夹中收集结果，在.mres文件中收集摘要数据，并作为单个分析进行后处理
- **2020 R1新增:**
  - 默认求解器管理工作区布置的首选控制
    - 允许在监控新运行时自动加载用户指定的布局
  - 云图的响应点筛选:根据输入和输出参数的指定标准，从响应云图中筛选操作点
    - 比如：不包括压力比小于1的操作点
  - 响应面质量度量
  - 网格更改后，对操作点求解器继续运行 “Continue All”

Response surface created from an operating map solve

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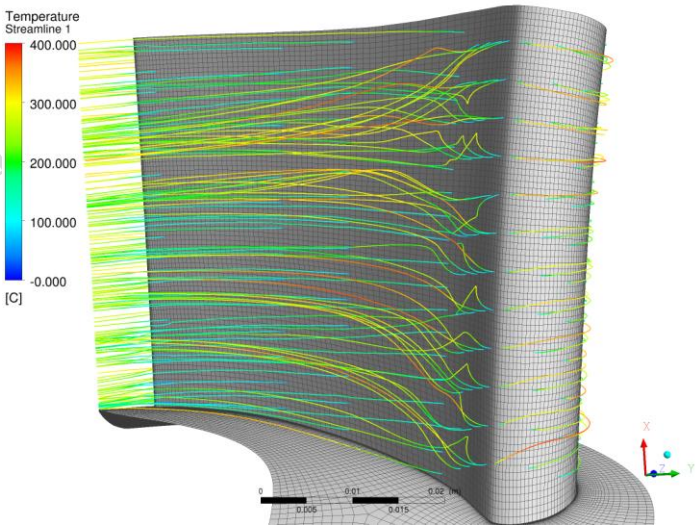
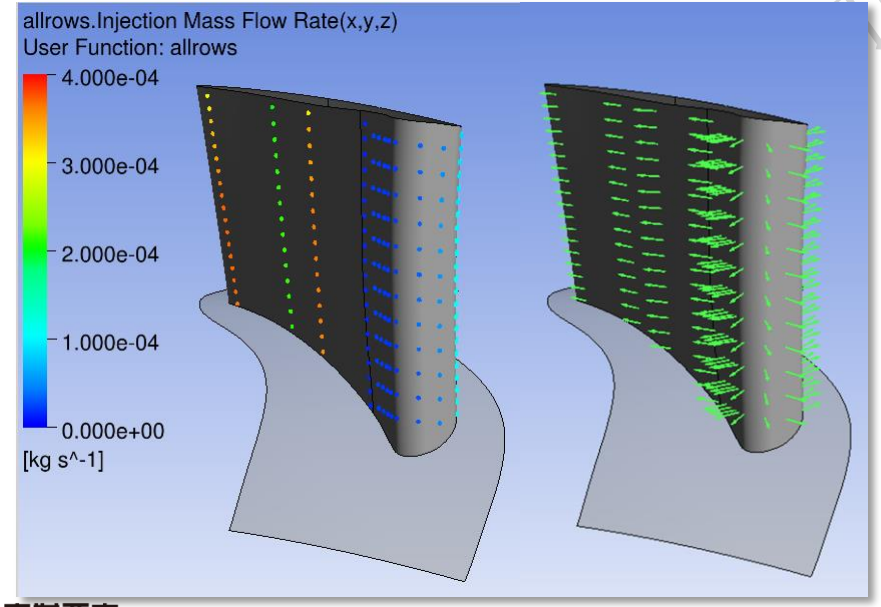
# 叶片膜冷却

**模拟透平叶片中冷却流动的快速、实用解决方法**

- 适用于所有的叶片排方法 (steady, transient, harmonic, CHT)




**2020 R1新增:在CFX-Pre中设置时注入区域的可视化**

- 用注射变量着色注射位置
- 用矢量图显示注射方向

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# 气泡/沸腾流动的多尺度组(MUSIG)模型

**非均匀MUSIG (I-MUSIG)模型允许对一系列气泡尺寸进行模拟，每个气泡尺寸都有自己的速度场**

- 与气泡/沸腾流相关
- 消除了单一气泡速度场的假设

**MUSIG和I-MUSIG模型现在可以与RPI壁面沸腾模型完全耦合**

- 考虑气泡聚结、气泡破裂、大量凝结和沸腾
- 允许预测过冷液体沸腾的临界热流密度(CHF)
  - CHF描述了能够传递到流体中的最大壁面热流
  - 当壁面热流超过CHF，靠近壁面会形成过多的蒸汽，从而减少了对过冷液体的传热，导致过热

TU Munich (TUM) test facility, wall boiling in a vertical channel planar copper heater. Courtesy of Dr. G. Bloch, Prof. T. Sattelmayer, Technische Universität München

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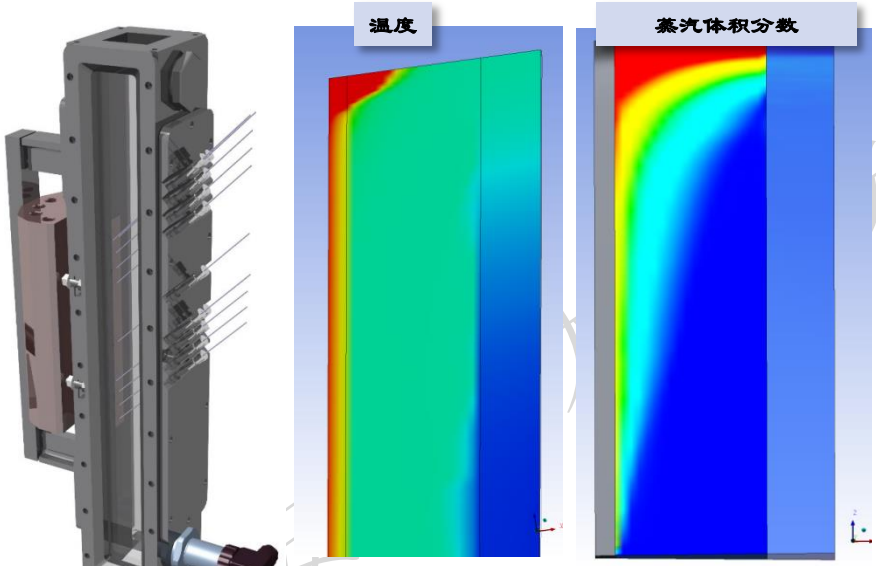
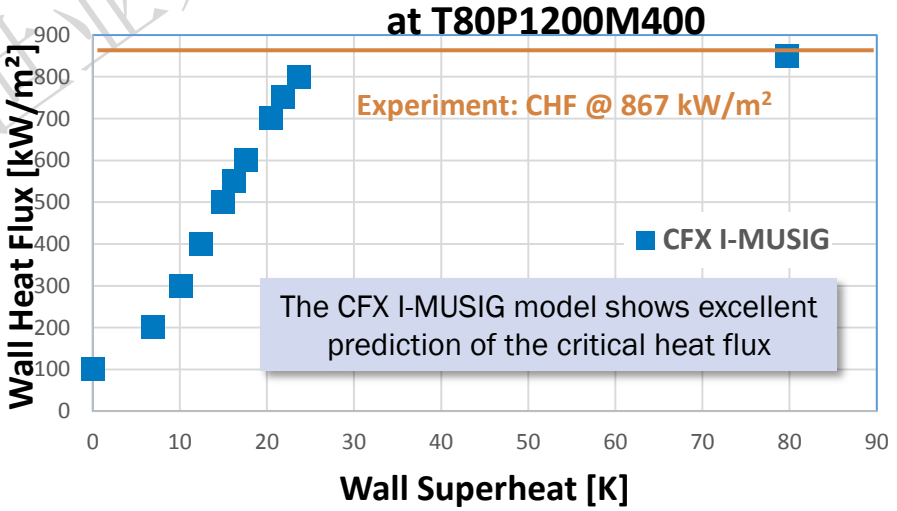
# 用I-MUSIG和壁面沸腾预测临界热流密度

## COSMOS-L Test Facility - Karlsruher Intitut für Technologie (KIT), Germany




使用I-MUSIG模型时的温度和蒸汽体积分数云图；壁面热通量 = 850 kW/m2




Courtesy of Dr. Stephan Gabriel, Karlsruher Intitut für Technologie (KIT)

For full results for the TUM and KIT test facilities see: *Lifante C. et al., 2019, Prediction of convective boiling up to critical heat flux (CHF) conditions for test facilities with vertical heaters, Proc. ICONE-27*

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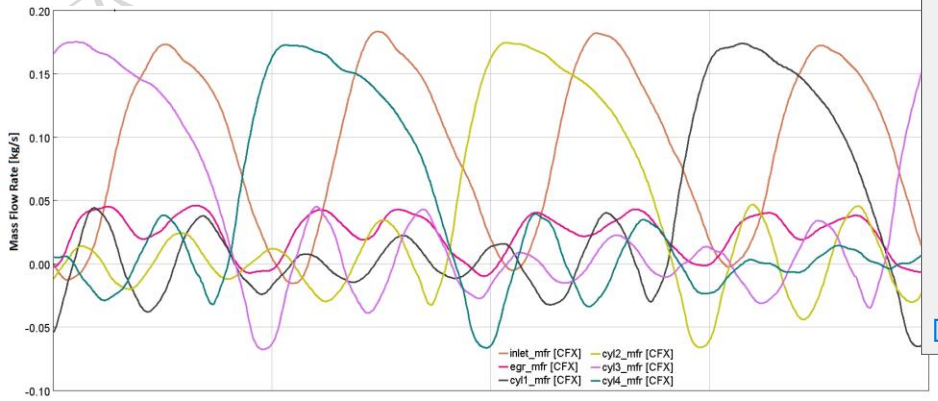
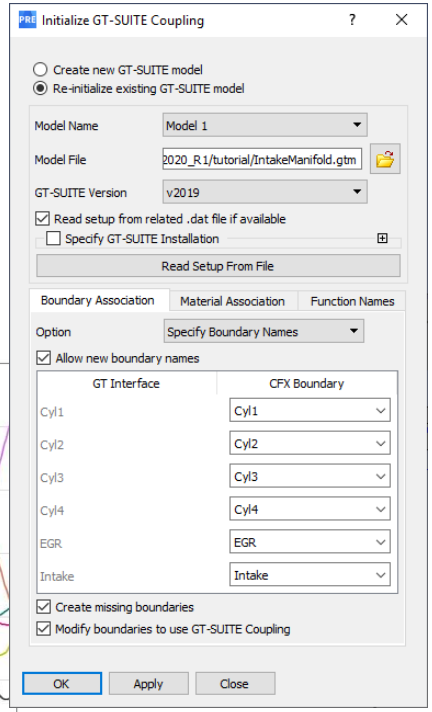
# CFX – GT-SUITE 耦合 (beta)

## 在流动边界处耦合CFX 和GT-SUITE

- 将CFX模型(如涡轮增压器)耦合到GT-SUITE
- 内置流程
  - “Tools > Initialize GT-SUITE Coupling”
  - Mapping and Auto-Setup of Boundaries
  - Mapping of Species/Materials
  - Validation checks




*Mass flow rates at coupling boundaries*

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# 谢　谢

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